International Union of Forestry Research Organizations
Union Internationale des Instituts de Recherches Forestières
Internationaler Verband Forstlicher Forschungsanstalten

Increasing Productivity of Multipurpose Lands

IUFRO Research Planning Workshop for Africa
Sahelian and North Sudanian Zones
Nairobi, Kenya
9-15 January 1986

Compiled by
Les W. Carlson
Canadian Forestry Service
Government of Canada
and
Keith R. Shea
U.S. Department of Agriculture
Forest Service

August 1986

Material contained in this report is reproduced as submitted and has not been subjected to peer review or rigorous editing by staff of the Canadian Forestry Service.

89-03061/

SPONSORS

The organization of the workshop has been made possible by contributions in cash and/or in kind made by (in alphabetical order):

- ADAB (Australian Development Assistance Bureau)
- Burkina Faso (Institut de Recherche en Biologie et Écologie Tropicale: IRBET)
- CFS (Canadian Forestry Service, Government of Canada)
- FAO (Food and Agriculture Organization of the United Nations)
- France (Office de la Recherche Scientifique et Technique Outre-Mer, Centre ORSTOM de Dakar, and Centre Technique Forestier Tropical: CTFT)
- GTZ (German Agency for Technical Cooperation)
- ICRAF (International Council for Research in Agroforestry)
- IDRC (International Development Research Committee of Canada)
- Kenya (MAB Kenya Arid Lands Research Station: KALRES)
- ODA (Overseas Development Administration of the United Kingdom)
- Senegal (ISRA/CNRF and Direction des Eaux, Forêts et Chasses)
- UNDP (United Nations Development Programme)
- UNESCO (United Nations Educational, Scientific and Cultural Organization: Man and Biosphere Programme and Regional Office for Science and Technology for Africa)
- USAID (United States International Development Cooperation Agency: Agency for International Development)
- USFS (United States Department of Agriculture, Forestry Service)
- WB (The World Bank)

Copies of this publication may be obtained free of charge from Les W. Carlson, Canadian Forestry Service, Government of Canada, 351 St. Jospeh Boulevard, Hull, Canada, K1A 1G5.

Reprint

CONTENTS

	Page
Foreword Bob Buckman	1
Executive Summary	2
Introduction Oscar Fugalli	6
Address of Welcome Hon. J.J.M. Nyagah	8
IUFRO Address El Hadji Sene	14
Keynote Address J.P. Lanly	17
Agroforestry Research and Development: Agroforestry Practices for the Solution of Food, Fodder and Fuel Shortages Michel Baumer and Peter Wood	22
Research on and Development of Natural Regeneration Techniques for the Silvo-Pastoral Management of Existing Forest Resources E.G. Bonkoungou and R. Catinot	89
The Management of Indigenous Trees and Shrubs for the Rehabilitation of Degraded Rangelands in the Arid Zone of Northern Kenya H.F. Lamprey	125
Selection and Genetic Improvement of Indigenous and Exotic Multipurpose Woody Species; Including Seed Collection, Handling, Storage and Exchange FAO/O. Souvannavong and C. Cossalter	139
Improvement of Woody Planting Stock through Manipulation of Symbiotic Microorganisms in the Sahalian and Sudano-Sahelian Zones (SSSZ) Y. Dommergues, J. Gorse, B. Dreyfus, J.P. Colanna, S. Badji and A. Niang	165
Research on and Development of Nursery Practices and Techniques for the Establishment and Management of Fuelwood Plantations, Including Water Harvesting and Distribution FAO/C. Cossalter and O. Souvannavong	187
Nursery and Fuelwood Plantation Practices in Arid and Semi-Arid Zones of North-East Africa F.B. Armitage and J. Burley	263
Research Priorities Keith R. Shea	283
Closing Remarks J.A. Odera	293
Post-Mortem Meeting with Donors and Technical Advisors Tim Resch	295

Post-Mortem Meeting with Country Representatives Les Carlson 301

Appendix I: Agenda 303

Appendix II: Participants 306

Appendix III: Reseach Priorities 316

Appendix IV: Forestry Research Networks 319

Appendix V: Guidelines for Programme Evaluation 328

FOREWORD

Bob Buckman

Vice President, IUFRO

The African regional workshop, "Increasing Productivity of Multipurpose Lands," was the third in a series of regional planning efforts organized by the International Union of Forestry Research Organizations (IUFRO). The purpose of these efforts was to identify and flesh out a research and extension program aimed at the solution of some of the most pressing problems in Asia, Africa, and Latin America. While the organization of the exercises differed somewhat, all required substantial participation of scientists from developing countries themselves.

IUFRO's Special Program for Developing Countries had its roots in discussions among John Spears of the World Bank, Dr. Marco Flores Rodas of FAO, and officers of the Union itself at the XVII IUFRO Congress in Kyoto, Japan in 1981. The World Bank and UNDP provided funding for a Special Coordinator, Oscar Fugalli, formerly of FAO. Fugalli's main tasks were to organize three workshops in Asia, Africa, and Latin America on research themes of common interest to those regions and to seek additional funding for the Special Program.

In addition, Division 5 (forest products and utilization) of IUFRO, with financial support from the International Development Research Centre of Canada (IDRC) and several IUFRO affiliate institutions embarked on two companion efforts in forest utilization research under the leadership of Dr. Walter Kauman of the Centre technique du Bois et de l'Ameublement (CTBA) of Paris.

Planning documents for two efforts have been completed including 1) Increasing Productivity of Multipurpose Tree Species: a Blueprint for Action -- aimed at increasing forest productivity in Asia, and 2) Improved Utilization of Timber Resources in South America; a Program for Action. The proceedings of the African workshop represent the third such document. A fourth, concerning improved utilization of Asian timbers, is in preparation. A fifth workshop related to multipurpose woody species in social forestry for Latin America is being planned.

It is IUFRO's hope that the proceedings and plans developed by these exercises will form the basis for increased financial support for forestry research and extension from bilateral and multilateral donor agencies, from redirection and strengthening of support within participating countries themselves, and from a variety of private and non-governmental sources. Plans thus developed tend to have a short half life. But they provide a starting point around which a variety of national and global interests can coalesce to strengthen national programs of forestry research. And the plans form a foundation for cooperative networks that will assure rapid and continuous sharing of information among scientists and among those who need research findings to do the on-the-ground jobs of forestry.

EXECUTIVE SUMMARY

The new IUFRO Special Program for Developing Countries presented at the 1981 Congress was designed to provide for research planning workshops in Asia, Africa and Latin America. A Special Program Coordinator, Oscar Fugalli, was appointed to organize the three workshops on research themes of common interest to those regions and to generate funding from donor organizations for this special program.

The first workshop for Southeast Asia was held in Kandy, Sri Lanka, July 16-28, 1984, and resulted in "A Blueprint for Action."[1]

The Research Planning Workshop for Africa "Increasing Productivity of Multipurpose Lands" was organized by the International Union of Forestry Research Organizations (IUFRO). It was the second workshop developed as an outcome of the 1981 IUFRO Seventeenth Congress in Kyoto, Japan.

The workshop was held at the Kenyatta Conference Center in Nairobi, Kenya, January 9-15, 1986, and was attended by over 90 people. Fifteen African countries were represented: Burkina Faso, Cameroon, Cape Verde, Chad, Ethiopia, Gambia, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Somalia, Sudan and Tanzania.

The organization of the workshop was made possible by financial or in-kind contributions by the following (in alphabetical order):

ADAB (Australian Development Assistance Bureau)

Agriculture Canada, Canadian Forestry Service

Burkina Faso (Institut de Recherche en Biologie et Écologie Tropicale: IRBET)

FAO (Food and Agriculture Organization of the United Nations)

France (Office de la Recherche Scientifique et Technique Outre-Mer, Centre ORSTOM de Dakar; and Centre Technique Forestier Tropical: CTFT)

GTZ (German Agency for Technical Cooperation)

ICRAF (International Council for Research in Agroforestry)

IDRC (International Development Research Centre of Canada)

Kenya (MAB Kenya Arid Lands Research Station: KALRES)

ODA (Overseas Development Administration of the United Kingdom)

Senegal (ISRA/CNRF and Direction des Eaux, Forêts et Chasses)

---

[1] Shea, Keith R. and Les W. Carlson (compilers). (1985) Increasing Productivity of Multipurpose Tree Species: A Blueprint for Action. IUFRO Planning Workshop for Asia. Kandy, Sri Lanka. July 16-28, 1984. IX + 100 pp.

UNDP (United Nations Development Programme)

UNESCO (United Nations Educational, Scientific and Cultural Organization: Man and Biosphere Programme and Regional Office for Science and Technology for Africa)

USAID (United States International Development Cooperation Agency: Agency for International Development)

U.S. Department of Agriculture, Forest Service

WB (The World Bank)

The workshop was organized around seven topics, each in the form of a proposal which was discussed by all participants. The proposals are summarized below:

1. **Agroforestry Research and Development: Agroforestry Practices for the Solution of Food, Fiber, Fodder and Fuel Shortages by Michel Baumer and Peter Wood.**

This proposal addressed shortages of fuel, food and fodder and proposed 12 research priorities along with estimated costs:

- Biology and reproduction of Capparaceae.
- Hedges as producers of fodder.
- Browse management.
- Fodder productivity of browse species.
- Leaf growth.
- Fuelwood productivity of windbreaks.
- Fuelwood productivity of saline lands.
- Fuelwood productivity in various agroforestry systems.
- Production of food by woody plants.
- Indirect impact of woody plants on food production (tree-crop interface).
- Cacti for fodder production.
- Atriplex for fodder production.

Each of the priorities were reviewed, specific activities listed and the inputs required identified along with a proposed schedule and estimated costs.

2. **Research and Development of Techniques of Natural Regeneration for the Silvo-Pastoral Management of Existing Forests by E.G. Bonkoungou and R. Catinot.**

This proposal identified specific areas of research to be conducted:

- Ecology (bioclimatology).
- Inventory and photointerpretation.
- Methodology to estimate stand volume and productivity.
- Stand regeneration.
- Management of stands and their productivity.
- Stand dynamics.
- Development of an agroforestry system based on natural regeneration.

- Development of a pasturing system based on natural regeneration.
- Bush fires.
- Special research.
- Appropriate research plots.

In addition, suggestions were made for technical coordination, education and extension and for dissemination of scientific and technical information. A budget covering contributions from donors and the participating countries and essential personnel and equipment is provided.

3. The Management of Indigenous Trees and Shrubs for the Rehabilitation of Degraded Rangelands in the Arid Zone of Northern Kenya by H.F. Lamprey.

This proposal which relates primarily to the arid zone of Northern Kenya concerns:

- Regulation of wood harvesting.
- Regulation of livestock browsing of trees.
- Logistic support for woodland management.

A work plan, time table and cost estimate are provided.

4. Selection and Genetic Improvement of Indigenous and Exotic Multipurpose Tree Species including Seed Collection, Handling, Storage and Exchange by O. Souvannavong and C. Cossalter.

This proposal covers roughly three climatic areas -- Sudano-Sahelian, Sahelo-Sudanese and Sahelo-Saharan areas. Three main objectives are envisioned: select best and most productive plant stock, conserve endangered genetic resources and use selected reproductive materials and planting stock. The work proposed is divided into four projects each with objectives, a series of activities, input and budget:

- Exploration and conservation of genetic resources.
- Evaluation and selection of genetic resources.
- Qualitative and quantitative improvement in seed supplies.
- Coordination of species and provenance selection.

5. Developing and Using Biotechnologies in Forestry and Agroforestry in the Sahelian and Sudano-Sahelian Zones by Y. Dommergues, J. Gorse, B. Dreyfus, J.P. Colanna, S. Badji and A. Niang.

This proposal concerns two technologies which can be adapted to increase the tolerance of trees to the harsh Sahelian and North Sudan conditions:

- Selection and genetic improvement.
- Manipulation of symbiotic microorganisms.

In addition to a program of research, training and transfer of knowledge and extension are proposed along with the projected budget for facilities, equipment and supplies, staff and a preliminary network.

6. Research on and Development of Nursery Practices and Techniques for the Establishment and Management of Fuelwood Plantations, including Water Harvesting and Distribution by C. Cossalter and O. Souvannavong.

This proposal focuses on seven West African countries. The general problem, research needs and knowledge dissemination and training needs are defined. Eight projects are outlined in considerable detail along with cost estimates. The projects are as follows:

- Continuing training for forestry staff.
- Preparation of analytical bibliographies specific to dry tropical regions in the field of nurseries, plantation establishment and management.
- A directory of forestry research in dry tropical Africa.
- A directory of forestry development in dry tropical Africa.
- Nurseries: Evaluation of techniques used, dissemination of knowledge, and programming of further research.
- Plantations: Evaluation of techniques used, dissemination of knowledge, planning of further research.
- Developing a site description method.
- Hardening, under Sahelian conditions of gum acacias propagated by tissue cultures.

Each of the proposed projects are outlined in considerable detail along with estimated duration and costs.

7. Nursery and Fuelwood Plantation Practices in Arid and Semiarid Zones of Northeast Africa by F.B. Armitage and J. Burley.

This proposal focuses on five Northeast African countries, an area characterized by harsh climates, variable low rainfall and mostly poor soils with low humus content and moisture retention capacity.

A checklist is provided to facilitate review and preparation of any detailed project concerned principally with fuelwood. Major topics for consideration are:

- Sociological and institutional research.
- Choice of species/provenance.
- Seed research.
- Nursery research.
- Plantation establishment.
- Plantation management and protection.
- Basic rhizosphere studies.
- Tree improvement.
- Basic economic studies.
- Development of tools and their use.

In addition, extension, training, provision of information and program management should be included.

Following the workshop, separate discussions were held with representatives of the countries and the donor organizations to critique the workshop and propose suggestions for future IUFRO-sponsored workshops. These discussions are summarized elsewhere in this report.

INTRODUCTION

Oscar Fugalli
Special Coordinator for Developing Countries, IUFRO

In closing the Introduction to the Proceedings of the IUFRO Research Planning Workshop for Tropical Asia (Kandy, Sri Lanka, July 1984) I wrote: "At the end of the workshop we found ourselves still not very close to the targets, even though considerable progress has been made. A bolder initial approach might have yielded better results, which we have now adopted for the companion IUFRO Research Planning Workshop for Africa (Sahelian and North Sudanian Zones) due to be held in January 1986".

The African workshop has now been held, in Nairobi (Kenya), as scheduled. What has the bolder approach yielded? Somewhat more than in the case of the Asian Workshop but, again, not as much as we expected: though a couple of steps forward have been taken, there are quite a few that still need to be taken to hit the target.

Which target? To my mind, the target is to use IUFRO research planning workshops as tools to be of the greatest possible, and most expeditious, assistance to developing countries as well as to donor agencies.

The conceptual work accomplished at Kandy must not be underestimated. But it left practically all the project formulation effort undone. And it is well known that the major stumbling-block in international cooperation is the dearth of adequately designed projects, especially at the group-country level (regional, sub-regional).

It was a stroke of good luck that, in the case of the African workshop, we could profit from the outcome of an investigation on forestry research priorities in Africa carried out by FAO, and from the results of the Technical Consultation on Wood Energy Research and Development in Africa organized by FAO in November 1984. This enabled us to identify research priorities, as perceived by the countries concerned, before the workshop actually commenced, and not during, as in the case of the Asian workshop. We could thus dispense with the first of the two weeks of the Kandy workshop and commission "draft project documents" rather than the more traditional "position papers".

To the best of my knowledge, and in the forestry field at least, this Nairobi workshop of IUFRO's has been the very first meeting convened to scrutinize draft project documents. Results? Authors of such documents are like artists and difficult to regiment. The interpretation of what was expected of them has varied substantively amongst them, as the reader will be able to ascertain for him/herself. I must confess I was scared before the workshop began and in its very initial phases. Gradually the interest shown by the African forest scientists and administrators, as well as the understanding coupled with the will-for-involvement of the representatives of the donor agencies, made me relax and I began believing it was going to be a reasonably successful meeting despite the novelty of its approach. Which it was, as it was confirmed by two post-mortem discussions held immediately after the workshop with a cross-section of the African participants and with the representatives of the donor agencies: we were encouraged to pursue the draft-project-document approach also in preparing for the forthcoming IUFRO Research Planning Workshop for Tropical Latin America due to be held in 1987. The gist of the post-mortem discussions was that such an approach should not be discarded simply because it is difficult to be fully successful. Everybody concerned should rather make an effort to refine it and improve on it, also through a more standardized methodology.

These Proceedings will now be submitted formally by IUFRO to the planning authorities of the African countries concerned as well as to the headquarters of the donor agencies expected to have an interest in the kind of projects discussed during the workshop. It will be suggested to both parties that they might wish to get together in order to ascertain whether, how and to what an extent they wish to cooperate.

It would be most difficult, and perhaps impossible, to line up in order of priority all those whose contributions have made it feasible for the workshop to take place in the way it has taken place: from the African countries that have decided to participate; to Kenya that has also offered host facilities; to the numerous donors listed elsewhere in these Proceedings who have decided to help; to the authors of the draft project documents who have toiled before the workshop writing up their paper, during the workshop to defend it, and after the workshop revising it in the light of the criticism and comments made by participants; to the planning leaders who have distilled the real significance of the discussions and have later put together these Proceedings; to the Chairman and Vice Chairmen of the workshop who skillfully have managed to have adequate discussion on all important items despite the limitations in time; to ICRAF without whose assistance my task would have been manyfold more arduous; to my two collaborators CT and MS who, unobtrusively, have oiled the wheels of the workshop to enable it to run smoothly from beginning to end. Let us lump them all in an unprioritized "THANK YOU" and .... hasta la vista en America Latina.

ADDRESS OF WELCOME

Hon. J.J.M. Nyagah
Minister for Environment and Natural Resources, Kenya

Mr. Chairman, distinguished participants, guests, Ladies and Gentlemen:

On behalf of Kenya Government and of myself, I wish to welcome you all to Kenya. It is my hope that besides the rather heavy schedule of work before you, you will find some time to relax - at least to mix "work with leisure" (or is it pleasure!).

I must also at the outset take this opportunity to thank all of you here, attending this conference/workshop, be you guests, observers, experts, technicians, or sponsors. Of the sponsors I single out particularly IUFRO (International Union of Forestry Research Organizations) and ICRAF (International Centre for Research in Agroforestry) out of several other individual organizations, for their involvement in the preparation and organization of this conference now being held here in Nairobi.

Your workload as shown in your very comprehensive agenda, shows that you will tackle such matters of great importance to the nations of Africa, and indeed the rest of the world - such as:

* Agro-forestry research;
* Rehabilitation of endangered sites;
* Silvo-pastoral (trees/animals) management;
* Tree improvement and seed supply;
* Maintenance and enhancement of soil fertility;
* Nursery practices and techniques,

and no doubt any other matters of both interest and importance, that will emerge during your deliberations for the achievement of objectives and goals of this workshop - be these matters political, social, technical, economic or otherwise.

My dear colleagues - I call you so, because although I am not personally an accredited member of this workshop as such, I, like you, am equally concerned with the subject matter before this celebrated body of experts. We look forward to achievement of successful results. As Kenya's Minister in-charge of Environment and Natural Resources, I wish to assure you that I will be very happy to receive from this conference any useful guidance and contributions; such contributions that will render themselves pragmatically and easily implementable.

Mr. Chairman, I feel persuaded to believe, that any of my similarly placed colleagues in any African nation, will take the same view. So, as you get on with this work, do please bear this target in mind and within view.

You are and will be dealing with things concrete; with situations, actual, imagined and/or expected, as well as with people. So while you are considering your subject from the scientific approach in order to find solutions to the problems in this field, please do also take the human factor/element into consideration most seriously - for his likely reactions, prevailing cultural/traditional attitude to known and/or identified problems, as well as to any suggested solutions.

Please allow me to mention in passing an often ignored truth, just as a cautionary remark. Many problems in Africa, be they health, economic, educational, religious, etc., have somewhat remained unsuccessfully solved, or have apparently been met with some resistance, as to earn the outsider experts' judgement of people being primitive, backward and ignorant, thus presenting unnecessary stumbling blocks to progress and development. The truth is indeed the simple fact that the so-called experts themselves fall culprit and victims of their own "ignorance", in not realizing and recognizing the importance of/ absolute necessity of involving the local community to assist them in their process of finding the needed effective solutions to the prevailing problems. The local people's participation and input in some aspects of research are of paramount importance, if useful and practical solutions of a problem are to be achieved.

Your task during this conference will no doubt be concerned with both causes and solutions to the many ills being experienced in Africa in the field of environment.

Dear friends, don't we already know the reasons why:

- croplands are over-cultivated;
- rangelands are over-grazed;
- forests are cut;
- irrigation projects turn good cropland into salty barren fields;
- good lands become bad;
- soil bakes into near-rock, or becomes sand or salt-crusted dirt.

On the whole most of us know that when hitherto productive land converts into wasteland, through human mismanagement, a situation known as "desertification" or better still "desertisation" occurs; with the resultant climatic conditions that bring about untold human miseries in very many forms. Such conditions as droughts usher in famine - causing starvation and death to human beings and animals and affecting crops of all species.

Can we really say that we do not know why today in Africa:

- the forest areas are diminishing?
- the soil erosion (wind, water) is on the increase?
- the social-economic situations are prevalent and are on the increase?

One of the causes of these is the rate of uncontrolled human and livestock population growth. Both man and his livestock compete for food/survival from a land surface area that never increases in either quantity or quality but somewhat deteriorates annually in quality especially. In desperate pursuit of survival therefore, man eats into the remaining fertile lands - usually the forests - by cutting down trees and natural forests in search of further fertile agricultural lands for food production. This he usually does for a short time before be abandons it later when it shows signs of infertility through apparent poor crop yields - then he shifts further into virgin lands.

These virgin lands could be forests, or rangelands. He needs such for both himself and his livestock. Man does this as a matter of routine tradition, culturally inherited from his forefathers. Today in addition to this rather inherited routine he does it because of pressures brought about by modern economic forces, which compel him unknowingly to destroy his environment, in order to meet the daily demands. Today man cuts trees not only to cultivate food, or build his houses, but in order to produce timber and to burn charcoal for sale to urban centres and maybe export. Man also does this in order to grow cash crops for export, despite their meagre returns to him and the country, and he also does cut down trees to provide land settlement for his ever enlarging family/population.

In his imperative need to provide for his survival, man seeks and pursues the easiest available and immediate methods. This results in finding new fertile areas for food production, bearing in mind that he has a rather large family of unproductive dependent members to support and take care of. The easiest options therefore are such as shifting cultivation and earnings from sale of forest products, etc.

Mr. Chairman, I hope I have said enough convincingly, for you experts to consider man as an integral part of finding solutions to our current pressing environment problems.

It is gratifying to note that we in Africa are not alone in the concern for arresting any further environmental deterioration and for improving it. Our foremost concern today is the need to devise readily acceptable and effective possible remedial measures. We know that we have the world with us in this matter, albeit in the final analysis it may be and must indeed be: "Conserving Africa for Africans must be principally by Africans." We know that the world concern with Africa is with us, especially through the international effort clearly being demonstrated through interest shown in workshops such as this as well as others held elsewhere in the past, and/or planned to be held elsewhere in the future.

Mr. Chairman, most participants here are no doubt aware of for instance the:

- F.A.O. (Food and Agricultural Organization of the United Nations) declaration of the year 1985 as the "International Year of the Forests."
- The 9th World Forestry Congress in Mexico (July 1985) expressing concern particularly regarding the forest degradation in the TROPICS, and also in the effect of acid rain on the TEMPERATE FORESTS - and how to save these.
- The 12th Commonwealth Forestry Conference in British Columbia (Canada) last September - its deliberations cautioning the world on the dangers of depletion of forest resources to the survival of a large part of the world's population.

  It endorsed F.A.O.'s recommendations of action programme priorities on forest development in the tropics; as well as the findings of a Joint World Resources Institute Task Force Study (by World Bank and U.N.D.P.) calling for accelerated involvement programme representing almost doubling of current levels of forest conservation investment.
- The 90 years experience of the International Union of Forestry Research Organizations (IUFRO) especially in its activities of harmonizing research internationally, thus affecting a free flow of results of forestry research.

I am informed that it was in a conference held in Kyoto (Japan) 1981, that it was resolved to invite IUFRO to strengthen its activities in developing countries; as a result of this, the first workshop was held in Sri-Lanka in July 1984 coming out with a blueprint for action for Tropical Asia. It was at the same time decided to hold this second workshop here in Nairobi for planning a similar cause of action for SAHELIAN AND NORTH SUDANIAN ZONES.

Mr. Chairman, all this international consciousness on the importance of forests is a healthy sign that we in Africa are not alone. We must therefore act in co-operation with those of our friends in the world in finding workable and lasting solutions to our problems - problems created and being aggravated by recent substantial and sustained human and livestock population growth; as well as the threat posed by desert encroachment/enlargement, claiming on the average annually some 100 000 hectares of Africa's productive lands. Researchers have produced rather frightening statistics on this which indicate that some 55% of Africa is threatened by desert, and that 45% is prone to severe droughts.

Mr. Chairman, you will have to come out of this workshop with answers that will reassure and satisfy Africa's population with sufficient wood: or provision of wood -

- wood for fuel and building poles,
- wood to cover the earth, to preserve/conserve water,
- wood for catchments and to furnish the earth with its green beauty or greenness,
- wood to provide food - both for subsistance and cash crops. Food means crops and meat etc. for cash/crops and timber and fuel.

It is said that wood provides 90% of staple energy consumption in Africa and that so far no substitute seems to be available in many countries. Besides this energy provision to man, trees provide him with fruits and nuts; seeds and pods; honey and fodder etc.

Distinguished delegates, it is further frightening to learn from statistics produced by researchers that: in 1975 there were about 202 million hectares of natural forests in Africa, but today this is being depleted at a rate of 7.5% annually, through clearing of natural vegetation for settlements, over-grazing, over-exploitation of commercial species - especially for timber, charcoal and burning of pastures. Sometimes under careless terminology used by some in describing shrubs as "useless bushes" etc.

Lest I appear to lose myself in general problems of Africa and the world scenes in these matters, and being a Kenyan do please permit me to briefly say a few things about the country I know best - Kenya.

Like most countries of the world today, Kenya is aware of the dangers posed to our environment by bad land management and usage. Kenya has therefore, decided to tackle the problems in a two-pronged policy approach viz.

- the policy of Forest Conservation, and Protection,
- the policy of better land management and usage.

The Government and the people of Kenya have been so fortunate in having a President who is personally interested and committed to the conservation of forests and sustainable natural resources. In his personal example and through his practical and repeated wise advice to the Kenyans H.E. the Hon. Daniel Toroitich arap Moi has effectively guided this nation in the implementation of the conservation policies mentioned above everywhere in the republic. He in person has not only set the example of working with his own hands with/among his fellow Kenyans, but he demonstrated this by travelling to work with the Wananchi in this remedial type of conservation work in many parts of this Republic - particularly in combating soil erosion, conserving water, and in schemes of afforestation. He has even launched a campaign of tree planting by the political party youths of this country through harambee financial contributions. The response to this Presidential call for contributions is proving very successful.

Mr. Chairman, Kenya inherited at independence some 3% of forest land area (equivalent to approximately 2.35 million hectares). The nation is determined to increase and enlarge this forest land area. In addition to this we must take greater care of our existing natural forests, and our national tree plantations (mainly of exotic species). We must establish and plant trees of suitable species for all ecological zones so as to meet needs of our farmers in their traditional and new settlement areas. The settlement areas are those parts of Kenya that were formerly Colonial European owned: "White-highlands", as the colonialists called them. Agro-forestry approach therefore is a must. Right species must come out from suitable right seeds. Success in this scheme calls for effective scientific nursery management - as well as in arousing in our people, awareness of the importance of trees, as a prerequisite for better land usage for increased and sustained food productivity and water availability. With this foremost, in the minds of the community and their leaders, the other aspect of commercial trees resources will automatically follow.

The country is now fully aware that the population growth in Kenya today far outweighs the existence of arable land available and likely to be available. Aware of this, Kenyans are therefore continually being educated and reminded to observe the imperative needs to:

a) control population growth, and
b) manage the land better through soil and water conservation.

It is Kenya's hope that by the year 2000 water will be available within very easy reach of every Kenyan's home throughout the Republic; and that also the country will be able to meet the estimated national wood needs of 2.3 million cubic metres of industrial requirements, and 30 million cubic metres for fuel.

Mr. Chairman, we in Kenya do value constructive advice and pragmatic policy advice from friends. By the same token we equally like to share our experiences for what they are worth with our friends - so you should know us that way.

Now that you do, let me tell you that we are in the middle of experimenting, and implementing some development programmes in 28 Districts out of the 41 Districts of Kenya. The 28 Districts I have singled out have arid and semi-arid conditions and yet they support 20% of Kenya's population and 50% of Kenya's livestock population. Conditions in these areas are agriculturally rather hard and sometimes harsh. Water in these areas is scarce and trees few.

We have nonetheless recorded successes in some places, and disappointment in others; but we don't give up, and we don't intend to give up. Our ruling KANU party's motto is: "Forward ever, Backward Never".

Distinguished delegates, let that brief comment on Kenya here suffice, and let me therefore try and wind up so that you will have enough time to get on with the job that brought you here at NAIROBI - from your beloved country/home. You will have an opportunity during this workshop to:

- plan for better Africa's forest management;
- find ways of possible sources for funds and manpower resources to implement those plans and programmes that you will recommend;
- to go back home more enriched with new ideas from the contact and personal exchange of ideas you have made here with people who like you, are equally concerned and experienced in the relevant fields of the subject under discussion;
- find better and more effective ways of involving for participation the people (both the leaders and the rest) in the areas concerned in order to bring about the desired goals.

Finally, do please allow me to quote from a book entitled "Africa in Crisis - the causes, the cures of environmental bankruptcy" by Lloyd Timberlake. Mr. Timberlake concludes: "Environmental bankruptcy has not been caused by the stupid African peasant, as so many of these governments and aid agencies and their experts like to think.

"On the contrary, it is the African peasant who best understands how and why he or she has been forced to damage the environment on which they depend, and it is he or she who is the key to rebuilding their continent."

"To ground Africa's future in an environmental reality which is maintenable, to produce development that is sustainable, will require a great deal of common sense; common sense from the South; common sense from the North. What is increasingly apparent in the African Crisis is that common sense is a very rare gift."

May I also refer you to a feature article appearing on P.16 of yesterday's daily paper, THE DAILY NATION, entitled "An African Journalist" in a column of personal opinion, suggesting that Western media can help Africa by permitting expression of an African perspective on his predicament - and attributed to a Mr. Djibril Dialo. Summarizing very briefly Mr. Dialo's case, one would say that the memories of the past colonial history of Africa still linger on in the minds of some Western experts, and also among our own African Governments and leaders, in that one of the principal causes of the current crisis is that Africa has been too willing to accept the guidance of those who never really understood the dynamic nature of its societies and how they worked.

At this juncture therefore I wish your deliberations every success, and every participant the best wishes for the year just started; and to Africans' future the greatest of developmental success, Abundant Prosperity, not only in material forms, but also in peace, love and unity everywhere and in every other desired ways. On this note, may I declare this IUFRO-Sponsored Workshop formally open.

Thank you.

IUFRO ADDRESS

El Hadji Sene
Member of the IUFRO Executive

Honorable Minister of the Environment and Natural Resources, Fellow workshop participants,

The meeting which opens today is the culmination of a lengthy process which, since the 17th Congress of the IUFRO (Kyoto, Japan, 1981) by way of Kandy, Sri Lanka (where a similar workshop was held for Asian countries), expresses the growing involvement of the International Union of Forestry Research Organizations in the study of problems encountered by forest research planning, reinforcement and expansion in developing countries. In this context, and on behalf of the IUFRO executive, of which I am a member for Africa, and of its President, Professor D. Mlinsek and myself, allow me to say a few words and express several thoughts.

President Mlinsek sends his compliments, and hopes that your days of work here in Nairobi will be fruitful and yield results that can be of significant use to forestry research in this zone for each of the institutions you represent and for each of you in your activities and programs.

I believe that, as you begin your work, a certain amount of information should be provided to define the framework of study and thus avoid any misunderstanding about the significance of IUFRO involvement, particularly in a zone where individual researchers are not greatly familiar with this international non-governmental organization. I am certain the Special Coordinator will do so, so I will simply say:

- that the IUFRO is a non-governmental organization freely constituted by forestry research institutions (some 600 units) and by individual research scientists and foresters; its means are relatively limited, but its potential is vast, given the size of the scientific community adhering to its statutes (over 10,000 forest scientists) and the availability and credibility of this community;
- that its major duties are to provide information, impetus and cooperation between institutions and research scientists with a view to guidance;
- that its involvement in forest research problems in developing countries, and particularly in drought-affected zones, is very recent.

This involvement, in my view, must essentially rest on a certain number of principles, including the following:

- it must help to underline and identify the priorities of such research by providing the researchers concerned with opportunities similar to this workshop to arrive at a consensus on priorities;
- priorities, thus defined openly by researchers and foresters of the zone in question, will certainly be the best expression of the issues and obstacles opposing the development of local populations and economies of the countries concerned; accordingly, they must form the basis upon which IUFRO will sensitize donors and cooperating agencies;

- projects and programs stemming from this exercise, in order to bear fruit, must in turn meet a number of basic requirements, specifically
  - make possible the primary participation of national and regional institutions in their implementation; considerable efforts have already been deployed to associate such regional and sub-regional institutions in the preparation of this workshop; these efforts and the response to them must continue;
  - provide opportunities for training and consolidation of these institutions;
  - present further opportunities for the training of researchers;
  - authorize balanced cooperation between the institutions of countries within the zone and those of developed countries;
  - be conceived to announce in their areas of coverage the advent of local capabilities and mechanisms designed to last beyond the life of initiating projects.

All of this, my dear colleagues, applied to the Nairobi workshop, means that all the proposals made in the preparatory documentation are of value only insofar as they will have generated interest and discussion, provoked and undergone modification, adaptation and improvement, and finally, in their new forms, garnered your support; such support will certainly entail your commitment to implement them in the field, each according to his own concerns - either individually or as part of cooperative projects - but always in a spirit of cooperation and exchange. I believe that these principles, if respected, will make possible the total expression of your capabilities and of those of your institutions in a dynamic regional and international cooperation. They will allow you to bring original solutions to the major problems of forestry research stemming from the development of countries in the zone. They will allow you to draw extensively on local knowledge and experience, in particular the mass of traditional practices and technologies of local populations accumulated in population/vegetation/resources/food/habitat and other interfaces.

This heritage must be gathered, preserved and improved by research before it deteriorates and becomes ultimately obsolete and forgotten, something that would be a tragic cultural and scientific loss and an enormous setback.

In closing, I want to add that we owe a great deal of thanks to the national and international organizations that made possible the preparation and holding of this workshop. They have remained faithful to their traditional concerns and the only valid response to these concerns will be your will to ensure that the workshop meets your needs and produces useful projects for forestry research adapted and capable of providing solutions to our problems. The consultants poured all of their knowledge and spirit into the work they prepared for us; they deserve our thanks and also our criticism, in the noble and committed sense of the word, it being the sole process by which we can make the material which they deliver to us our own.

Special Coordinator Mr. Oscar Fugalli, as usual, deployed an abundance of spirit, energy, consciousness, openness, etc.; all of these will certainly contribute to the success of the workshop. Grazie dottore. Finally, for our reception in Nairobi, we should also thank

ICRAF, which contributed to the organization and logistics - not a simple task; and we should once again thank the government of Kenya, which allowed us to hold our meeting in a friendly and caring country, where human beings commune with nature.

My dear colleagues, following the year 1985, which was so significant for forests, foresters and trees because it had been declared the International Year of the Forest by the FAO Council and observed as such by the vast majority of countries, and following the 9th World Forestry Congress, our workshop is one of the very first post-1985 forestry meetings; it is hoped that we can inaugurate this new period with the only thing that can breed further success, namely the success of this workshop.

I thank you.

KEYNOTE ADDRESS

J.P. Lanly
FAO

I should like to begin by bringing you the best wishes of Mr. Edouard Saouma, Director General of FAO and Mr. Marco Flores Rodas, Assistant Director General and Chief Head of the Forest Department of FAO, for the sucess of this IUFRO Workshop.

FAO is particularly appreciative to have been invited by IUFRO to give this opening address, and indeed the opening address at the first workshop, held in Sri Lanka in July 1984, was also given by FAO, by its Asst. Director the Regional Director for Asia and the Pacific. This invitation by IUFRO is quite deliberate. As many of you know the IUFRO Special Programme for Developing Countries arose from a resolution from the 17th World Congress held at Kyoto in 1981, at which the problem of forestry research in these countries was considered, based upon a joint document of FAO and the World Bank. FAO gives the highest priority to this programme, recognizing through its field programmes and its contacts with national institutions in its 158 member countries the enormous requirements for forestry research in the third world, and has given continuous support to IUFRO in its efforts in this regard.

This support has taken the form of the services of its headquarters and field staff, and of consultants in the preparation and follow-up to the Kandy Workshop. It has also included contributions to the present workshop, with the assistance of the Centre Technique Forestier Tropical, of project documents, including the Selection and Improvement of Indigenous and Exotic Multipurpose Trees (which you will discuss the day after tomorrow), and research and development in nursery techniques, plantation establishment and management for West Africa which will be considered next Monday or Tuesday. Finally, FAO has already begun its contribution to the third workshop planned in this series, which will cover Latin America, with the preparation of a document on the selection of species for arid zones.

FAO considers this second workshop is without doubt the most important, particularly as the 16 countries represented here form the majority of the 26 countries recently affected by the food crisis and which are the priority region for FAO activities. It is not inappropriate here to remind ourselves of certain facts about these countries to illustrate the grave and deteriorating socio-economic situation in these countries.

Food production per person has gone down by about 2% between 1980 and 1984. The bill for imported food, in dollars, quintupled between 1970 and 1985. Without a real technological revolution in the agricultural sector it is difficult to see how things cannot get worse in view of the rapid population growth. Subsaharan Africa has the fastest growing population of any region of the world, and at 3.2% annually the population will double every 22 years. The image of a under-populated region becomes daily more unreal. By 2025 (only 40 years away), Nigeria will have about 300 million people, about the same as India when it achieved independence; Ethiopia will have over 100 million inhabitants and sub-saharan Africa as a whole would have 1.2 billion people, against 360 million in 1980. It is not until 2025 that we begin to see the fertility of certain countries approach a level of replacement, and it will be necessary to wait till the close of the 21st century before populations stabilize.

Faced with this enormous population growth, the dry areas of Africa - the physical base on which human activity, especially agriculture is based - deteriorate a little more each day. The continued use of land husbandry methods which are now becoming inappropriate, insufficient inputs and irrigation, and the demands of human and animal populations in excess of carrying capacity are some of the causes of degradation of the natural environment, in other words what we have come to call the desertification which today affects Sahelian and North Sudanian Africa. All the components of the land are affected - soils degraded through wind and water erosion, water resources diminishing and water tables lowered; woody vegetation (forest and pastoral resources) destroyed by clearing, or degraded by exploitation beyond their regenerative capacity. And all this against a background of uncertainty about climatic change and cycles of drought. Rainfall which we like to regard as "normal" and the good rains of 1985 in the region must not allow us to forget the food shortages and indeed famines which have plagued the countries of the region over the last 20 years, and especially in 1983-4.

Because of the interdependence between agriculture and food on the one hand, and the environment on the other, any strategy addressing the food crisis which ignores environmental conservation is bound to run into difficulties sooner or later. Similarly, any programme attempting to restore the natural environment can only have temporary success if it ignores the needs of agriculture and rural development. Put another way, agricultural and environmental rehabilitation must go hand-in-hand or neither will succeed. This is one of the principles underlying the recent initiatives taken by FAO to address the food crisis in dry Africa, of which I will list briefly four of the most important.

The first is a programme of agricultural rehabilitation covering the 16 countries represented here plus 9 others, comprising 300 projects costing $250 million, 80% of the money for which is already assured.

The second is an in-depth study of the problems of food production in Africa, proposed in the Harare Declaration adopted by the African Ministers of Agriculture and Rural Development at the 13th Regional Africa Conference of FAO in 1984. An important part of this is devoted to the conservation of the resource base.

The third is the support given to COMIDES, the Interministerial Conference for a Concerted Programme for the Fight Against Desertification and the Protection of Nature, which brings together 26 countries of north, west and sudano-sahelian Africa, which, at its second meeting last November, adopted a programme of 29 major projects of which some addressed the themes of this workshop.

The fourth and last initiative is the cooperative technical support given to the French Government for dry Africa north of the equator, for an International Conference on Tree and Forest to be held from 5 to 7 February, this year, and which will raise consciousness of the forestry problems of dry Africa and reinforce international cooperation in this area.

Forestry is in the front line of professions which are qualified and able to bring a long-lasting solution to the food and environmental crisis of dry Africa. Indeed, natural woodlands or trees incorporated into pure forestry systems or in the numerous agrosilvopastoral systems which already exist, or are feasible, form an integral part of the resource base for human activities, especially agricultural, and contribute to food security in a number of different ways. These include: the protection of soils against wind or water erosion; the stabilization of sand dunes; soil improvement through the production of organic matter and the fixation of nitrogen; water conservation; microclimate amelioration, production of fuel and timber, production of forage for animals and of fruits and other foods for humans, and the generation of wealth from forest products, thus improving the socio-economic well-being of landless rural populations. The problem of fuelwood alone, which contributes 80% to 90% of the total energy consumed in the 16 countries in this workshop, and almost 100% in their rural areas, is challenge enough to forestry and foresters, posed to them by the situation in dry Africa.

In the forestry and silvopastoral field a great deal has already been achieved, much of it over many years. Both positive and negative experiences are available to enable us better to highlight likely solutions to problems, as well as actions which are best avoided. It would be inefficient and unfair to ignore these lessons. But we must look hard at the evidence - not only the range of possible actions whose effects may be more extensive than realized, but also at what has been achieved up to now. This is especially so if we consider, as is the usual way of foresters, the needs not only up to the year 2000 but 20 and 30 years into the next century.

Such enormous efforts as are needed presuppose a political will to carry them out, and there are encouraging signs which allow some optimism. Did not the African governments at the last OAU Summit commit 20% - 25% of public investment to general agricultural development, which must mean some increase for both forestry and agrosilvopastoral activities? Have not anti-desertification programmes, master plans and other long term forestry plans been adopted which demonstrate the increasing importance given to conservation and forestry development by governments in dry Africa? This political will must be maintained and reinforced, however, and foresters have an essential role in creating awareness among decision-makers and in influencing public opinion. Nevertheless there are at least two other essential ingredients for viable forestry development. The first is the support of local communities for forestry projects without which they are bound to fail to a greater or lesser degree, which has all too often been the case in the past. And the second, equally necessary, is good research, which is why this IUFRO Workshop is so important. First of all, it is a concrete response to the need for forestry research which does not have, or has lost, the importance it should have in this region of the world. The current situation regarding forestry research in Africa - which FAO has reviewed and will shortly publish as a compendium - can be greatly improved. Throughout the region, to a greater or lesser extent one notes the lack of national research policy, the absence of vocation or career structures, inadequate resources, and an absence of research programmes which address real needs.

I have spoken of good research as an essential element in forest development, but what is "good research"? I would say that in North Sudanian and Sahelian Africa, good forestry research should contain the following four characteristic elements.

Firstly, the priorities and hierarchy should clearly be related to those problems that it is likely to be able to solve, and it should benefit a majority of people in the country concerned. And, of course, this presumes that the research priorities have taken into account the actual socio-economic condition of the country. This point is important. To omit fuelwood production from research on the basis that fuelwood can be replaced by fossil fuels, when the countries cannot possibly substantially increase their imports, is clearly nonsense. In general terms the close relationship between research and development can hardly be over-emphasized. It is not a question of denying the research worker the minimum flexibility to operate, but he must be accountable, allow his research programmes and their socio-economic value to be evaluated, and finally must be prepared to modify his programmes in the light of these evaluations.

Secondly, research must be carried out at different levels - basic research, applied research, and project-oriented research. The distribution at the three levels has to take account of several factors, especially the resources available, the most important problems to be solved and the corresponding issues. The poorer the country and the more urgent its problems the more important will be applied and project-oriented research, and the less appropriate basic research.

Thirdly, good research should support the analysis of traditional knowledge and practices which are too often ignored in favour of ill adapted modern technologies. The old saying "an old man who dies is a library in flames" is true in dry Africa as elsewhere - and this is especially so in the areas that concern us here, in agrosilvopastoral systems, in the management of natural forests and plantations, and in the utilization of local multipurpose trees.

Fourthly, and lastly, good research should produce results that are easy and economic to apply, and acceptable to those whom they are intended to benefit, principally the rural communities. It is useless to discover yet another "miracle tree" if it is rejected for one reason or another by the people it is intended to serve. Or again, to put into practice a system of management of natural forests that ignores the neighbouring populations and their needs.

The five themes selected by IUFRO for this Workshop for which you have received draft documents for regional projects, seem to us in FAO to reflect well the priorities for forest research in the region, and also to balance basic, applied and project research satisfactorily. This was discussed by us with the coordinator of the programme more than a year ago. As for the two other factors referred to above, namely the utilization of traditional knowledge and know-how, as well as the socio-economic acceptability of the results of research, we suggest that they are taken into account both by those preparing the final versions of the documents, and as well by those putting the projects into practice.

The seriousness of the forestry problems in developing countries as a whole and in dry Africa in particular has given rise to a large number of initiatives from multilateral or bilateral agencies, and non-governmental organizations, and continues to do so. But because they have sometimes addressed the wrong problems, or duplicated efforts, and because the achievements have always fallen short of actual needs, the FAO committee for Forest Development in the Tropics recently adopted a Tropical Forestry Action Plan to encourage harmonisation of effort and to reinforce international cooperation in the forestry sector. The meeting held in the Hague last November at which a larger number of development organizations were represented, was the first step in this plan. Whether it be north-south or south-south, this need for harmonisation of effort and reinforcement of international cooperation should guide you in the regional forestry research projects that are formulated here, which should also bear in mind projects that have been recommended, formulated or eventually put into practice, that have arisen from other meetings at other times. I refer particularly to the recommendations and to the Plan of Action which was proposed following the Technical Consultation on Research and Development on Wood Energy for Africa, organized by FAO in Addis Ababa in November

1984, for which a regional project will arise soon, as well as the 29 major projects already referred to from the second session of COMIDES. In the important area of forest seed selection and distribution at a regional level, COMIDES has already defined a project, and several proposals for bilateral assistance exist. It would be valuable for you to take into account these different proposals to avoid duplication of effort and competition, both of which would be both absurd and wrong.

I would like to end by asking you to excuse me for taking so long, but please be assured that the length of my presentation is an indication of the importance attached to this Workshop by the organization that I represent here. It is important for several different reasons. Firstly, because it concerns dry Africa which is central to FAO's preoccupations, being the region of the world affected most persistently by the food crisis. And then because it is in the conditions of dry Africa that the contribution of social forestry is most important, a genuine programme of forestry with multiple objectives which FAO is seeking to promote in developing countries. Finally, it is important because FAO has a great interest in the activities of IUFRO, with which it is closely and formally associated. This is particularly so with the Special Programme for Developing Countries, to which it has contributed and intends to continue to contribute actively, especially at this Workshop where it will be represented throughout.

To conclude, I wish your labours at this Workshop every possible success, and that they will lead rapidly to concrete forestry research and development projects in Sahelian and North Sudanian Africa. And my best wishes to you all for a very happy stay in Nairobi and this beautiful country of Kenya.

AGROFORESTRY RESEARCH AND DEVELOPMENT: AGROFORESTRY PRACTICES FOR THE SOLUTION OF FOOD, FODDER AND FUEL SHORTAGES

Michel Baumer and Peter Wood
International Council for Research in Agroforestry (ICRAF)
P.O. Box 30677
Nairobi, Kenya

1. INTRODUCTION

Agroforestry (AF) is defined as the deliberate incorporation of woody perennials into a land use system together with agricultural crops, and/or animals on the same area of land either in a time sequence or simultaneously in mixture, and between which there are ecological and economic interactions.

The development of suitable intercropping species and practices covers almost the whole of AF which consists essentially of a range of technologies or practices which can be used to meet identified land use problems and constraints. An essential to research planning is therefore a clear identification of the problems to be solved.

2. ECOLOGICAL CONSTRAINTS IN DRY AFRICA

The following is not an exhaustive survey, but only a few examples of some of the problems that AF development may be able to alleviate.

Aridity and dryness

Aridity as well as desertification may have various intensities, and several attempts have been made to classify them.

The classification by Le Houerou and Popov (1981) of the eco-climatic zones of intertropical Africa combines many criteria. It takes into consideration the de Martonne classification (1928) which makes a distinction between tropical zones with unimodal rainfall regimes and equatorial zones with bimodal rainfall regimes. Unimodal distributions may occur in dry zones (as in the Lobito Bay in Angola) or even in very dry ones (as the Horn of Africa and especially its northern coast); bimodal distributions may be found in very humid zones (as around Conakry, Guinea).

Dry months are classified as those which have a mean rainfall in millimeters less than twice the mean monthly temperature in Celsius degrees (Bagnouls et Gaussen, 1953, 1957) or $P<2t$.

In West Africa at least, there is a coincidence of that formula with that of Prescott and Thomas (1979) of the evaporation from a naked soil surface ($e = 0.4 E^{0.75}$), and that of Penman ($P< 0.35$ PET) corresponding to the water requirements of most of the African crops in the days immediately after sowing, to show that the cropping season really begins when monthly rainfall reaches 50-55 mm (or 1.6 - 1.8 mm/day).

The UNESCO classification (1979) is useful for an approach on a country scale: it considers that aridity increases as precipitation decreases and evaporation rises. Following Riquier and Rossetti (1976), the ratio $\frac{P}{Etp}$ where P is the mean annual rainfall and Etp the mean annual potential evapotranspirations is used to describe degrees of aridity:

Hyper-arid zone (A):	$\frac{P}{Etp} < 0.03$
Arid zone (B):	$0.03 < \frac{P}{Etp} < 0.2$
Semi-arid zone (C):	$0.02 < \frac{P}{Etp} < 0.5$
Sub-humid zone (D):	$0.5 < \frac{P}{Etp} < 0.75$

For each of the four zones subzones are distinguished, characterized by the mean "winter" temperature t_h (in Celsius degrees):

1	warm	$20 < t_h < 30$
2	mild	$20 < t_h < 10$
3	cool	$0 < t_h < 10$
4	cold	$t_h < 0$

Variations based on the average "summer" temperature t_e are also made:

a	very warm	$30 < t_e$
b	warm	$20 < t_e < 30$
c	mild	$10 < t_e < 20$

By combining these data, types of aridity are defined with a set of 3 symbols. For example a C3c region will be semi-arid with cool winter and mild summer.

Table 1 gives the distribution of aridity in most of the tropical countries of Africa.

Many other systems of classification of climates exist for dry Africa. One of the oldest and most practical was published as early as 1950 by Aubreville (Flore forestière soudano-guinéenne), which is based on the rainfall seasons index and on the mean annual deficit of saturation. The index is made up of three figures: The first gives the number of very rainy months (more than 100 mm), the third is the number of months which are ecologically dry (less than 30 mm rainfall), the second is the number of months which are intermediary. Such a system is simple and has a lot of validity.

For the sahelo-sudanian climate, the more characteristic index of rainfall seasons is 4-2-6 (but others are also found: 3-3-6, 2-3-7, 2-2-8, 3-1-8, 3-2-7, 4-1-7, 4-3-5 rarely and exceptionally 2-4-6, when the mean annual saturation deficit ranges from 11.5 to 22 mm, with an excessive annual variation, from 15.5 to 27 mm.

TABLE 1.

	HYPER-ARID				ARID				SEMI-ARID				SUB-HUMID			
	A1a	A2a	A2b	A3b	B1a	B1b	B2a	B2b	C1a	C1b	C2b	C3b	D1a	D1b	D2a	D2b
Angola			+					+			+					+
Benin									+				+			+
Botswana							+			+	+					+
Burkina Faso					+				+				+			+
Cameroon									+				+			
Cape Verde								+								
Central Africa															+	+
Ivory Coast														+		
Djibouti					+											
Ethiopia	+				+	+		+		+	+			+		+
Gambia													+			+
Ghana													+	+		+
Guinea														+		
Guinea Bissau														+		
Kenya					+	+				+	+			+		
Lesotho																
Madagascar								+		+			+	+		
Mali		+			+		+		+		+					
Mauritania		+	+		+	+	+	+	+							
Niger		+			+		+		+							
Nigeria					+				+				+			+
Uganda										+				+		
Reunion																+
Rwanda														+		
Senegal					+	+				+			+			
Somalia	+				+	+			+	+						
Sudan	+	+	+		+		+	+	+	+	+	+	+	+		
Swaziland																+
Tanzania						+	+			+	+				+	
Chad		+	+	+	+		+	+	+		+	+				
Togo													+			
Zaire													+			
Zambia										+				+		+
Zimbabwe										+						+

The indices of rainfall seasons in the sahelo-senegalese climate are 3-2-7 and, rarely 3-1-8; the mean annual saturation deficit ranges from 9 to 12 mm with a severe variation from 8.5 to 12.2 mm.

The sahelo-senegalese coast has a lower saturation deficit (5.3 to 7 mm) with a weak annual variation (3.7 mm) and an index of rainfall seasons of 2-1-9, 2-2-8 or 2-3-7, which makes it convenient for trials with Cactaceae.

The saharo-sahelian climate has 1-2-9 as the most common index (with variations 0-1-11, 1-0-11, 1-1-10, 0-3-9, 2-1-9 (very rare), 0-4-8 and 1-3-8; the mean annual saturation deficit ranges around 15 mm, with a very important annual variation (15 mm).

The saharan climate has indices of 0-0-12, 0-1-11, 0-2-10 or 0-3-9; the saturation deficit is usually over 20 mm.

Topsoils are unstable and subject to erosion from rain and wind. Several studies report erosion losses of 20-170 tons of soil/hectare/year. About a fifth of all African soils north of the Equator are already degraded by wind erosion. In the summer of 1969 alone, 60 million tons of fine soil was blown from the Sahara and Sahel to the Atlantic, carried by seasonal easterly winds.

Soil nutrients are often scarce, not only the major ones of N, P & K, but also micro nutrients. Nutrients are lost to harvesting, leaching and runoff, and soil fertility and crop yields rapidly decline. If not replenished, all available nitrogen in a field can be depleted by annual harvests in 4 years. Natural restoration of fertility by fallow may take as much as 20 years. Annual crops can take up half the readily available nitrogen in a single harvest. Organic matter is easily lost under high soil temperatures, thereby reducing the cation exchange capacity of the soil and accelerating nutrient leaching. In the dry areas of Africa, water is the main limiting factor for plant growth although soil salinity may be equally important in some areas. In wetter zones soil fertility may be more important.

Growing populations compete for food, fodder, land and fuel. Population increase is over 3% in many countries, which means that population virtually doubles every 20 years. In the Sahel, livestock populations now sometimes exceed the pre-drought levels of 1973. The area of land remains the same, or even decreases.

3. THE IDENTIFICATION OF PROBLEMS FOR AGROFORESTRY RESEARCH IN DRY AFRICA

The starting point for problem identification must be the individual land user, the small farmer or pastoralist. Various methods for identification of the perceived problems at this level exist, e.g. the Diagnosis and Design Methodology of ICRAF (ICRAF 1983a, 1983b) and the methods of farming systems analysis developed by the CGIAR institutes, notably IRRI, CIMMYT, and ICRISAT.

Following these small scale surveys, the identified problems can be classified and summarized, and the major problem areas in which AF can be expected to play a beneficial role identified. The major problems generally fall into the following categories:-

1. Shortage of fuelwood and other wood products
2. Shortage of fodder and browse
3. Shortage of food.

   To these should be added:
4. Lack of shelter
5. Lack of shade
6. Insecurity and risk
7. Low investment in rural development in the dry zones
8. Difficulties with fencing materials and protection
9. Diseases of humans, plants and stock
10. Shortages of water
11. Problems of land tenure.

Each of these can be related to a number of underlying causes, to which research must be addressed urgently.

4. UNDERLYING CAUSES OF THE PERCEIVED PROBLEMS

4.1 Shortages of fuelwood and other wood products

- Rising human populations
- Excessive lopping and cutting woody vegetation for local use and export
- Clearance of woody vegetation for agriculture
- Destruction of woody vegetation through uncontrolled grazing.

4.2 Shortage of fodder and browse

- Rising human populations
- Excessive cutting and lopping
- Uncontrolled grazing leading to pasture degradation
- Poor siting and control of water supplies
- Diseases & pests
- Predation and theft.

4.3 Shortage of food

- Shortage of land suitable for cultivation
- Soil fertility decline
- Soil erosion by water or wind
- Other soil problems - alkalinisation, salinity, waterlogging
- Crop exposure
- Climatic change, fluctuation and unreliability
- Low rainfall leading to lack of soil moisture
- Inadequate crop tending and lack of labour.

4.4 Lack of shelter and shade

- Disappearance of trees through overcutting and mismanagement.

4.5 Insecurity and risk

- Lack of freedom of movement for nomadic peoples
- Insecurity of land tenure leading to low investment in land productivity
- Unreliable rainfall and crop failures
- Crop losses from nomadic herds.

4.6 Low investment

- Dry areas of countries generally receive comparatively less investment in infrastructures, roads and other facilities, and extension services.

4.7 Fencing materials

- Shortage of cash to purchase material
- No suitable technology for live fences and hedges
- Widespread destruction of woody vegetation for brush fences.

4.8 Diseases

- In humans from low income, poor nutrition, poor living conditions
- In livestock resulting partly from poor nutrition
- In plants from low income (for pesticides), poor land use practice.

4.9 Water shortages

- Unreliable and highly variable river flow resulting from vegetation removal
- Uncontrolled run-off of rainfall
- Poor soil water retention, resulting from poor soil structure
- Silting of dams
- Unreliable rainfall
- High evapotranspiration losses.

5. POTENTIAL ROLE FOR AF PRACTICES

It is clear from the above that many of the problems have a strongly socio-economic bias, and also that many of the possible solutions to the problems need not involve AF at all. Examples of the latter include soil and water conservation works, and the production of poles or fuel in government-run woodlots. In this paper we are concerned with technological research topics, but in each of them there should be an element of socio-economic evaluation included.

The AF practices that have been identified as being used traditionally as well as those that have been developed scientifically in response to specific problems can be summarized under twenty eight headings as follows:-

Improvements to shifting cultivation practice
Planted tree fallows
Taungya
Alley cropping
Boundary planting with trees
Live fences and hedges - mainly with barrier function
 - multipurpose production function
Multipurpose trees dispersed on - cropland
 - rangeland or improved pastures
Farm woodlots
Fodder/protein banks
Trees as shelter for - crops (windbreaks, shelterbelts)
 - animals
 - homesteads

Trees for soil conservation - on bunds, terraces
- as strips
- as hedges

Trees for water management
Home gardens
Plantation crops combined with - lower storey tree/shrub crops
- herbaceous crops
- upper storey trees (shade or multipurpose)
- pastures or livestock

Livestock under trees
Sand dune fixation
Aquaforestry
Apiculture with forestry
Amenity forestry.

1. Improvement to shifting cultivation practices

The main problems of shifting cultivation are soil deterioration and falling productivity, particularly through soil erosion. Improvements can be obtained through intercropping, contour planting, windbreaks, and fences during the cropping phase.

2. Planted tree fallows

Either in shifting cultivation or in permanent agriculture, fallow periods are required for soil recovery. Planted trees, especially those that are nitrogen-fixing, can contribute to soil improvement and also provide wood, leaf material and food. They do not have to be retained to maturity to have a beneficial impact.

3. Taungya

The most commonly used form of AF by Forest Departments for the creation of forest plantations. As well as reducing costs, taungya can provide food, employment and improved weeding of the trees. Problems include rural poverty, land and crop tenure, tree-crop competition.

4. Alley cropping

The practice of hedgerow intercropping in which arable crops are grown in between hedgerows is more applicable to moist zones than dry, but it can provide wood, leaf material, food and shelter in dry zones and is particularly appropriate if irrigation water is available.

5. Boundary planting with trees

This is one of the simplest methods of incorporating trees into farming systems with minimal tree-crop competition, for the production of all tree products. The trees can be managed by lopping, pollarding, coppicing or felling. Some of the problems commonly encountered include diseases, and crop pests (especially birds and rodents).

6/7. Live fences and hedges

Live fences are defined as the use of trees to provide fence posts or to provide a line of posts close enough to form a barrier. They may be lopped above fence height for the production of material. Hedges are defined as lines of plants of one or several rows which form a continuous barrier and which are regularly cut back to form a dense interwoven mass of stems, branches and foliage. Questions include tree-crop competition, response to cutting back, productivity levels of different materials, and in arid zones especially, competition between plants in the hedge and termite resistance.

8. Multipurpose trees dispersed on cropland

Trees deliberately planted (or deliberately left during land clearing) on cropland have a variety of purposes including increase of soil fertility, production of wood, leaf and food. This is particularly so with nitrogen-fixing trees. Questions include management by lopping and pollarding, spacing, shading and competition effects.

9. Multipurpose trees on rangeland

Trees incorporated into rangelands have similar functions to those listed above. Questions include the palatability, digestibility and nutritive value of fodder, the benefits or otherwise of shade and shelter, and the protection of the trees at crucial periods.

10. Farm woodlots integrated into farm management

Simple woodlots on farms have been used for centuries; however, the use of species and management practices as an integral part of farm management is essential for classification as agroforestry.

11. Fodder/protein banks

In land use systems using animals the provision of fodder in the dry season, or in years of poor rainfall, is a problem where annual plants are used. Tree fodder can bridge this gap.

12-14 Trees as shelter

These generally produce wood, leafy material or food in addition to shade and shelter. Shelterbelts frequently (but not always) increase crop yields through beneficial effects on soil and micro climate. On animals the effects are generally on reducing heat stress and exposure. Around homesteads, shade and wind protection are often combined with food and fuel production. However, trees compete for water and nutrients with other plants, and therefore the main points to be studied are the design of tree planting patterns, and their management for optimum effect.

15-17 Trees for soil conservation

Trees can improve infiltration and reduce run-off and erosion, although the choice of the wrong species or inappropriate land management can on occasion actually cause erosion. Trees or hedges can stabilize soil on terraces, bunds or other soil conservation works, improve infiltration, and in all cases contribute woody and leafy material. The main consideration points are planting designs and long term management.

18. Trees for water management

Trees have been used successfully to lower water tables in waterlogged areas, thus creating soil conditions suitable for agriculture.

19. Home gardens

Most noteworthy in high rainfall zones, home gardens of complex mixtures of multipurpose trees and crops of all kinds may also be valid in drier areas. In all cases the outputs are multiple but include a wide range of tree products.

20-23 Plantation crops

These are tree crops grown for a particular purpose e.g., coffee, gum arabic. The choice of a herbaceous under-crop, or an overstorey of shade trees, with or without the incorporation of animals depends upon local conditions and traditions.

24. Livestock under trees

The situation where animals are kept under naturally regenerated trees is being considered in another paper at this meeting.

25. Sand dune fixation

The use of woody perennials to arrest sand movement can provide an environment suitable for wood, fodder, food and animal production, and also wildlife management, agriculture and recreation.

26. Aquaforestry

This includes mangroves in saline water, and other tree associations using fresh water, incorporate the production of fish and crustaceans.

27. Apiculture with forestry

Particularly important as honey and beeswax do not remove large quantities of biomass from a site. Bee-keeping can, of course, be carried out in almost all AF situations including shelterbelts.

6. PROBLEMS TO BE SOLVED BY AGROFORESTRY

There are four major general land use problems to which agroforestry and research must be addressed:

i. Shortages of fuel
ii. Shortages of fodder
iii. Shortages of food
iv. Soil conservation.

The present preliminary proposals address shortages of fuel, food and fodder. These shortages are evident upon a very wide scale in the countries with which this workshop is concerned. Zonal or national audits of the situation identify problems to be solved, but do not identify problems as perceived at grass roots level.

Numerous projects have failed in dry Africa, not because they failed to identify real problems, but because they were not obviously related to the concerns and aspirations of the rural people, and often gave precedence to national priorities (e.g. shortages of imported oil) rather than to local perceived needs (e.g. fodder production or fruit trees).

In agroforestry the methodology for identifying problems on which research should be based has been given high priority by ICRAF, which has developed a farming systems analysis methodology known as 'Diagnosis & Design' (D&D). The logical series of steps from preliminary diagnosis, through identification of possible agroforestry interventions (ranked for importance) to final identification and development of research programmes is described by ICRAF (1983) and Huxley and Wood (1984). Where research for trees on farms is one of the solutions, a logical step-by-step analysis is an essential preliminary to successful research (especially when it is "on-farm", an unfamiliar concept for most foresters). A full "D&D" analysis starting at the individual farm level and building to the national level may not, however, always be possible, or needed.

For the IUFRO workshop for which this paper has been prepared it has obviously not been possible to carry out any kind of D&D analysis, and it has been necessary instead to draw on the experience of a number of people, including the writers, to prepare a list of appropriate and relevant research topics. It should be emphasized that the preparation of research programmes by ICRAF would not normally be done without a preliminary analysis which identifies the interlinked nature of problems and their underlying causes. This subject is discussed in some detail in ICRAF, 1983b. It should be emphasized that most scientists in rural development are aware of the enormous developmental tasks involved in their work, and of the interrelationship between the many different problems. What is not easy, however, is to select topics for research in which useful progress can be made. Endless restatements of global problems such as desertification, poverty, malnutrition and fuelwood shortages are of no help in formulating research plans, though they remind us of the priorities. The research topics listed here, therefore, are deliberately only a selection of what might be undertaken, but the authors believe they are of special interest within the framework of agroforestry (and not under the other topics considered at the workshop). This has, in fact, been confirmed by several representatives of the countries present at the workshop (see Figure A.1).

The authors wish to emphasize particularly the importance of socio-economic studies in all AF work, and have already pointed out the importance of ICRAF's 'D&D' methodology in this respect. The principles should always be used in relating real problems to research. But socio-economic research should not be done in isolation and many examples are known where such work has had a minimal impact on development in the field. It is therefore recommended that it should be part of each field study.

Some problems are, of course, universal in the developing world, and do not need farm level studies to confirm them. The world-wide problems of fuelwood, fodder and food shortages are examples, and these are addressed elsewhere in this workshop, as well as under agroforestry here. It should be noted, however, that "D&D" exercises already carried out by ICRAF in dry zones have so often identified specific problems at the level of the rural dweller, that they also are clearly of very high priority.

Lack of cash crops for sale
Absence of shelter or shade
Insecurity and exposure to risk
Low government investment in dry zones
Shortages of fencing materials

Shortages of labour
Diseases of plants, humans and animals.

Some of these are addresssed in the research priorities listed below.

7. RESEARCH PRIORITIES

7.1 How to address shortage of fodder

What differentiates the dry areas from the others, is the fact that they are not often suitable for crop production but well fitted for animal production, because the sanitary environment is better for animals than in the humid areas. Consequently, we will consider first the fodder aspect: what researches are needed which could facilitate the development of agroforestry as an approach to the development of the dry areas?

At the conclusion of an International Symposium on Browse in Africa organized by ILCA at Addis Ababa, in 1980, Le Houerou presented an overview of the needs for research. His suggested priority topics are as follows in a suggested order or priority.

7.1.1 Biology and reproduction of Capparaceae

During the driest months of the year, many woody species of the Capparaceae family are a major source of protein (and of carotene and minerals) and of energy for livestock and for wildlife (which is too often neglected in management and development programmes). Little is known of the biology and reproduction of genera like Boscia, Cadaba, Capparis and Crataeva, and also of Salvadora (family Salvadoraceae).

A research programme is suggested on the biology, phenology and reproduction of these genera, to make possible their management within AF systems and to facilitate their domestication. Parallel research should also be conducted by animal nutritionists to ascertain the palatability of a few of the species on which different views are held by various authors: for example, the palatability of Boscia senegalensis has been questioned as is the toxicity of Capparis tomentosa. Research should begin on the most promising Maerua crassifolia and on other species which are widely known to be valuable as fodder.

7.1.2 Hedges as producers of fodder

As long as livestock continue to move in an uncontrolled manner, it remains impossible to establish effective land management. Hedges and live fences would greatly help in controlling, directing and organizing the movements of the animals even if they do not necessarily create effective paddocks. If properly designed, they could also play a role in the provision of food, fodder, fuel, medicines, and other minor products.

Research should be conducted in two or three important ecological regions attempting to define which species should be used, how they should be propagated and mixed, how they should be managed to maximize their production, and to minimize their negative aspects, such as harbouring pests.

7.1.3 Browse management

Very little is known about the management for browse of woody plants of the dry regions of Africa. Many biological characteristics of browse plants are not yet known preventing the preparation of exhaustive management plans. But aspects of management could immediately be improved if some research were to be conducted on methods and periodicity of cutting, including lopping, trimming, pruning and pollarding.

Questions to be answered include choice of the best cutting tools, the season of cutting, and the frequency and intensity of cutting. Research should be started on the behaviour of a few species frequently cut by shepherds during the dry season, such as Acacia tortilis and its subspecies, A. Seyal, A. nilotica, Balanites aegyptiaca and other species as appropriate. Clearly, research should take into account sites and climate. The final objective would be to obtain for each species a diagram showing the negative and positive impacts of various types of cutting systems in various environments and according to the desired final product (for example: what is the trade-off of fuel versus fodder in lopped Acacia albida?)[1/]

The management of cutting systems should also take into consideration the availability to animals of the browse material. (For example, in the miombo woodlands, fodder exists at the ends of the branches, but becomes available to animals only when trees are regularly cut at a suitable height to regenerate and to make young branches accessible to the animals).

7.1.4 Fodder productivity of browse species

Productivity of populations over wide areas, but also per individual, per species and per colony, are important data on which to base realistic planning. As pointed out by Le Houerou (loc.cit):

> "the determination of allometric relationships has enabled progress to be made, but the method also has its limits. The regression curves cannot necessarily be extrapolated from one colony to another, nor from one region to another for a given species. The uncertainty grows even greater when multispecific colonies are involved which is the usual case."

Systematic research on the productivity of some of the most important browse species should be developed, as well as on their impact on the productivity of the herbaceous cover they are associated with. Special consideration should be given to the importance of spacing in different combinations.

[1/] Faidherbia albida (Del.) A. Chev. = Acacia albida Del.

7.1.5 Leaf growth

Of very special importance to the fodder balance are the young leaves of woody plants which appear at the end of the dry season, before the rains, because they are often the only source of fresh fodder for livestock. Some species seem to require cutting back for optimum fodder production; response is genetically controlled and therefore a good subject for selection of desirable traits.

Research is needed

1) to scan populations in order to identify clones which come into leaf early, or which have high leaf/stem ratios
2) to understand the physiological and/or genetical processes which induce early growth or late fall of leaves. It is not impossible that the mechanisms which induce the off-season production of leaves in Acacia albida are genetically controlled and, if this is so, this characteristic might be transferable to other Leguminosae.

7.2 How to address shortage of food

Agroforestry has greater relevance to the agricultural domain than to that of forestry, and in fact more research is being and has been done in the field than in forestry. Our suggestions for research should be seen as supplementary to this effort and they are therefore limited to two groups of proposals: the direct production of food by woody plants and the indirect effects of such plants on crop production.

7.2.1 Direct production of food by woody plants

Apart from a small number of geographically limited studies, little is known as of the part played by food coming from woody plants in the daily diet of different populations (Timberlake, 1985). Many communities have important dietary elements from these sources and it would be valuable to explore this subject with teams of foresters, sociologists ad nutritionists.

7.2.2 Indirect impact of woody plants on food production

7.2.2.1 The tree-crop interface

Increased study of the biological/environmental interactions of mixed cropping is needed. Even for Acacia albida, probably the most studied species in Africa in this respect, the mechanism of its beneficial effect on annual crops, the particular role played by its own direct N-fixation especially in relation to age of tree, and the impact of the faeces of animals standing in the tree's shade, are not understood. The kinds of questions that need to be answered (see Huxley, 1984) include the choice and age of nitrogen-fixing trees to associate with groundnuts, the best distance for maize to be planted from a Leucaena hedge, the competitive behaviour of a particular species with crops in different rainfall regimes, etc. There are four different fundamental situations depending on the dominance of either crop, and widespread site-specific studies are needed.

7.2.2.2 Shelterbelt effects

The effects of shelterbelts on crop production have been very little studied in Africa and these require study. Design, that is layout, species and management for a range of products such as fuel or bee fodder in addition to shelter are a major priority.

7.3 How to address shortage of fuel

Agroforestry has a major role to play in the production of fuelwood and charcoal through most of its current practices. But knowledge is still scanty on the productivity of the various agroforestry systems. Consequently, a major research need is to accumulate and analyse data on fuelwood production in some major combined production systems on a site-specific basis.

7.3.1 Fuelwood productivity of windbreaks

Very little is known at the regional scale of the impact of large scale management systems of windbreaks and shelterbelts in enhancing productivity, and in controlling desertification. If a large scale network of windbreaks were to be established in Somalia, for example, to enhance the productivity of irrigated schemes, it would be an ideal opportunity to develop a complete R/D project on windbreaks and especially:

- to measure the biological productivity of various species
- to measure the quantity of fuelwood produced by various species under different management systems and to compare it in economic terms with other effects of the windbreak.

In additon, other questions could be studied at the same time, such as the impact of windbreak on the productivity of various crops, at various scales (e.g. near the windbreak, on the basis of the individual field, at the agricultural region level) with an analysis of production factors, such as temperature, evapotranspiration and wind erosion.

Research could start immediately on existing networks of windbreaks; one physical network could concern rainfed crops (la Maggia in Niger, Toupouri country in N. Cameroon, Kano in Nigeria); another could deal with irrigated windbreaks (Valley of the Nile in Northern Province of the Sudan); later on, a third network could address the windbreaks in rangelands of which they are very few to date.

7.3.2 Fuelwood productivity of saline lands

Over 10% of African soils are affected by salinization. Saline soils have low productivity, but in the current desperate situation in these areas, their potential contribution to production should not be neglected. Soils of dry lands affected by salinization may produce simultaneously, or alternatively, fuels and fodder, as has been demonstrated in Australia, China, Israel & USSR. It is therefore recommended that an agroforestry research programme be developed on the rehabilitation of saline lands, aiming at increasing their fuel and fodder productivity. Special attention should be given to various systems of management of woody vegetation in saline lands, and their effects on fuel and fodder production.

7.3.3 Fuelwood productivity in various agroforestry systems

Similarly, research is needed on the fuelwood productivity of a variety of agroforestry systems, especially hedges and alley cropping. It is also important to know more about the actual fuelwood production of the present systems, and especially of the fuel production of isolated trees voluntarily maintained on croplands, such as Acacia albida, Butyrospermum paradoxum, Tamarindus indica, Parkia clappertoniana, etc.

8. PROJECT PROPOSALS

8.1 The grouping of research components

For reasons of practicality to potential donors the proposals are based on small research components or topics which are then grouped into major project areas. Small projects may be easier to finance and are certainly easy to manage, monitor and evaluate. The four main projects and their components are:

PROJECT A: AGROFORESTRY FODDER SPECIES FOR ARID LANDS

Background: The paramount importance of fodder and browse in areas too dry for rain fed agriculture.

Components:
A.1 The biology and reproduction of the family Capparaceae.

A.2 The use of the genus Atriplex in arid zones.

A.3 The family Cactaceae for fodder (and food) production.

PROJECT B: AGROFORESTRY MANAGEMENT FOR FODDER IN DRY ZONES

Background: Where agriculture is practised in dry zones the production of fodder from trees in agroforestry systems is of very great importance to the farmer.

Components:
B.1 The management of hedges to produce fodder.

B.2 The management of trees for fodder production.

B.3 Fodder productivity and quality of selected browse species.

B.4 Phenology and physiology of leaf growth.

All the above have as a major objective the production of field management guidelines.

PROJECT C: AGROFORESTRY MANAGEMENT FOR FUELWOOD AND FODDER PRODUCTION IN DRY ZONES

Background: The growing of trees exclusively for fuelwood is difficult and unpopular in most dry zones, despite the shortages. Much fuelwood arises as a by-product from trees used primarily for other reasons.

Components:

C.1 The production of fuelwood and fodder by windbreaks (linked with component D.2 which examines environmental aspects of windbreaks).

C.2 The production of fuelwood and fodder on saline lands.

C.3 The production of fuelwood in various agroforestry systems (alley cropping, home gardens, farm woodlots, boundary trees and intercropping as appropriate).

PROJECT D: THE IMPACT OF AGROFORESTRY ON FOOD PRODUCTION

Background: Woody perennials in agroforestry systems can affect food production in two ways, either by direct production by the trees themselves, or by influences on other food-producing plants.

Components:

D.1 Food production by woody plants.

D.2 Studies on the tree crop interface (in various agroforestry systems to evaluate beneficial or antagonistic effects).

8.2 Prerequisites and activities in the proposed projects

All projects are presumed to begin with commitment by the participating institutions to work on the project according to the programme and to exchange information freely, and with the designation of a backstopping institution.

The activities begin for each component with a careful examination of existing information and with its dissemination in the network. Primary information sources will be given preference.

Agroforestry as a discipline often covers more than one ministry or research institution in a country; therefore coordinators have a primary responsibility to examine the links and problems of cooperation between institutions early on in each project. There are also links between components and between projects which must be fostered by coordinators.

8.3 Duration of projects

Each project has been set up to run initially for five years, subject to periodic internal and external reviews. Within each project, each component has a proposed duration, which will be similarly reviewed. Projects may be renewed with revised objectives, activities and timing at the completion of the original proposed period.

GENERAL REFERENCES

Bagnouls, F., et G. Gaussen. (1953). Période de sécheresse et végétation. Paris, C.R.Ac.Sc., 236:1076-1077.

Bagnouls, F., et G. Gaussen. (1957). Climats biologiques et leur classification. Ann. de géographie, 355(66):193-220.

Baumer, M., et P.A. Rey. (1974). Pastoralisme, aménagement, cartographie de la végétation et développement intégral harmonisé dans les régions circum-sahariennes. Genève, Institut d'étude du développement, Genève-Afrique, Acta africana, 13 (1) : 1-18.

Baumer, M. (1981). Rôle de Boscia senegalensis (Pers.) Lam. dans l'économie rurale africaine: sa consommation par le bétail. Rev. élev. méd. vét. pays trop., 34(3): 325-328.

Charreau, C., et F. Vidal. (1965). Influence de l'Acacia albida sur le sol, la nutrition minérale et les rendements des mils Pennisetum au Sénégal. Agronomie tropicale, 20(6, 7).

Dancette, C., et J.F. Poulain. (1969). Influence of Acacia albida on pedoclimatic factors and crop yields. African Soils, 14(1-2):143-184.

Dancette, C., et M. Niang. (1979). Rôle de l'arbre et son intégration dans les systèmes agraires du nord du Sénégal. Le rôle des arbres au Sahel. Dakar, colloque I.D.R.C.

Delwaulle, J.C. (1977). Le Gao Faidherbia albida). Aspects forestiers du Project Productivité de Dosso (Niger). Nogent sur Marne (France), C.T.F.T., 8p + 6p. bibl.

Huxley, P.A. (Ed) (1984). "Research Methodology for the Exploration and Assessment of Multipurpose Trees" (source materials and guidelines, compiled by P.A. Huxley, J. Burley, P.J. Wood and P.J. Robinson), ICRAF, Nairobi.

Huxley, P.A. & Wood, P.J. (1984). Technology & Research Considerations in ICRAF's "Diagnosis & Design Procedures". Working Paper No. 26, ICRAF, Nairobi.

ICRAF (1983a) Guidelines for agroforestry diagnosis & design. Working Paper No. 6, ICRAF, Nairobi.

ICRAF (1983b). Resources for agroforestry diagnosis and design. Working Paper No. 7, ICRAF, Nairobi.

Le Houérou, H.N. (1980). Browse in Africa. ILCA, Addis Ababa.

Le Houérou, H.N. et G.F. Popov. (1981). An eco-climatic classification of intertropical Africa. Rome, F.A.O., Plant production and protection paper No. 31, i + 40p. + 3 separate maps.

PROJECT DATA SHEETS

A. AF FODDER SPECIES

1. The Capparaceae
2. Atriplex
3. The Cactaceae

B. AF MANAGEMENT FOR FODDER

1. Management of hedges
2. Management of trees
3. Productivity and quality of selected browse species
4. Phenology and physiology of leaf growth

C. AF MANAGEMENT FOR FUELWOOD AND FODDER

1. Production in windbreaks
2. Production on saline land
3. Production in various AF systems

D. AF AND FOOD PRODUCTION

1. Production by woody plants
2. Tree-crop interface studies

PROJECT A - AGROFORESTRY FODDER SPECIES FOR ARID LANDS

This project is made up of three research components.

A.1. - Biology and reproduction of Capparaceae

A.2. - Saltbrushes in agroforestry

A.3. - Cactaceae in agroforestry

For the arid parts of dry Africa, the most common and best activity with regard to the physical and sociological environment, is extensive animal breeding. It is the only farming system which permits - if properly managed - a sustained and appreciable production in these areas. There are, of course, exceptions, like the oases, where agro-sylvo-pastoral systems exist, or like the oil fields, where extraordinary economic conditions permit artificial systems but on a small scale. More than 95% of the arid parts of Africa have extensive animal husbandry as the only possible activity. These arid parts cover millions of hectares and concern some one hundred million people, of which one quarter have pastoral activities exclusively, and out of which more than 17 million live in the South saharian and saharo-sahelian zones.

It was especially to alleviate the consequences of aridisation for these people that the present group of research projects was conceived. It is obviously not of the same significance to the various countries concerned; for some of them, they would probably prefer to give priority to research aiming at improving food production, especially in parts of their countries where rainfall is over 400 mm. But others have large areas in really dry zones where the only rational possibility of farming is extensive animal husbandry based on sound range management principles; this is the case for example in Chad, Djibouti, Mauritania, Niger, Somalia and the Sudan.

It should be kept in mind also that the three research components proposed here have not the same potential range of application. There is, for example, a proposal for a global agroforestry project on Cactaceae; but past research has already shown these plants appear to be of little value in most of the "Sahel". Meanwhile, they seem to be quite valuable for some specific areas where they have been introduced already, but unsystematically and without scientific observations.

This has happened in several countries in both coastal and highland areas. The level of interest in the countries concerned for the three research components is suggested in Figure A.1 which is based partly on information gained at the workshop.

RESEARCH COMPONENT A.1 - BIOLOGY AND REPRODUCTION OF CAPPARACEAE

Objective: to study the biology and productivity of those Capparaceae which are known or supposed to be good fodder, with the objective of collecting and disseminating information on them, and encouraging their utilization by multiplying them in silvopastoral systems where appropriate.

N.B. - The project has been established for three participating institutions.

Activities:

1. Recruitment of a part-time coordinator.
2. Preparation of state of knowledge on the fodder value of the Capparaceae.
3. Establishment of a research programme to be conducted by animal husbandry specialists on the appetability and nutritional value of the Capparaceae, specially those which are not unanimously recognized as good fodder (e.g. as Capparis corymbosa or C. tomentosa).
4. Establishment simultaneously by three different institutions of live collections of Capparaceae, starting with the following:

   Boscia senegalensis, B. angustifolia, B. salicifolia, B. minimifolia,
   Cadaba farinosa, C. glandulosa,
   Capparis decidua,
   Crataeva adansonii,
   Maerua angolensis, M. crassifolia,
   Dobera glabra, Salvadora persica, (Salvadoraceae).

   This will require the collection of seeds or transplantation of young plants, and will enable studies to be made on: seed harvesting and conservation, germination, characteristics of seedlings. One live collection at least should be established in the ecological zones: Bla, Blb, Cla, Clb, Clc, Dla, Dlb, and on the major soil types that are used on a large scale for grazing in the agro-ecological zone.
5. Plantation trials designed to determine the best planting methods, including protection of the young plants. A specific study would be to determine the timing and intensity of browsing possibilities with the living plant, and to establish management rules for each species, taking into consideration the environmental conditions.
6. Simple trials on vegetative propagation of the species concerned.
7. Growth, phenology and fodder production would be monitored, on the live collections and in some of the plantations, in order to establish management guidelines.
8. Exchange of research workers. Each of the three participating institutions would send a research worker for 2 weeks to the 2 other institutions. The same research worker would represent his institution in the mid-term evaluation seminar.
9. Seminars: 1) to adopt the agroforestry research programme
   2) for mid-term evaluation.

Countries concerned	Research Components A.1. Capparaceae	A.2. Saltbushes	A.3. Cactaceae
Burkina Faso	+ +	+	
Cameroon	+	+	
Cape Verde			+ +
Chad	+ +	+ +	
Djibouti	+ +	+	+ +
Ethiopia	+	+	+
Gambia			
Kenya	+	+	+
Mali	+	+ +	
Mauritania	+ +	+	+ +
Niger	+ +	+	
Nigeria		+	
Senegal	+	+ +	+
Somalia	+ +	+ +	+ +
Sudan	+ +	+ +	+
Tanzania	+		+

This is of course subject to further discussions.

++ Very concerned with the problem
+ Concerned with the problem

Figure A.1.

Inputs required

1. The part-time coordinator could advantageously be based in one of the backstopping institutions. He would have to prepare the agroforestry research programme, then to monitor and facilitate the even development of activities between the participating institutions and the exchange of information between them and the backstopping institutions. He would also be responsible for the dissemination of information. An important aspect of his role will be to ensure that the project benefits from all qualified institutions in the area, and that institutions which are not directly participating have regular links with the participating ones.

2. The state of knowledge could be established in six months by two young graduate (Animal husbandry or Range-management) - one English-speaking and one French-speaking - preparing a thesis with the backstopping of an international organization like ILCA or ICRAF. It would involve much bibliographical research, and correspondence (especially with the scientific institutions which have shown an interest in the project), one visit to ICRAF and/or ILCA and two or three visits to other institutions. Salary and daily subsistance allowance, secretarial assistance, costs of production of two bi-monthly and one final reports, expenses for searching computerized data bases and costs of editing the final report, would also be needed.

3. Four weeks consultancy for animal nutrition specialist to develop a proposal for research on palatability and nutritional value of the Capparaceae not unanimously recognized as good fodder.

4. Selection of land for establishing live collections, with fencing, clearing, ploughing, provision of water, as appropriate.

   In most cases, suitable sites may be found in or near existing nurseries or reserves, but the land will have to be committed for a long period (this applies also to the plantation trials in which data will be recorded).

   For the collection of seeds, it is expected that all scientific institutions interested in the project will agree to collect seeds and supply them quickly to one of the institutions operating the project. Non-African species would be bought abroad.

   Establishment of appropriate nurseries would also be necessary, together with appropriate equipment.

5. Plantation trials. The establishment of protected plots to study reaction to browsing and to develop management methodologies will require fencing or, better recruitment of watchmen with camel or donkey able to understand and to explain to animal owners what is going on in the protected areas.

6. Equipment for vegetative propagation trials: cutting tools, chemicals, protective materials, greenhouses, labels, markers, etc.

7. Monitoring equipment should include: measuring equipment, photographic equipment, weighing scales, and a 4-wheel drive vehicle with contribution to fuel, maintenance and spare parts for 4 years.

Proposed duration: 5 years

Months		
0 - 6	State of knowledge	
	1,2	bibliographical research at ICRAF and ILCA
	2,3	correspondence; meetings with backstopping organizations
	end of 3	first interim report
	4	field tour
	5,	continuation of correspondence
	5,6	writing, editing and typing final report
5 or 6	Agroforestry research proposal (4 weeks consultation)	
5 - 24	Seminar to adopt the agroforestry research proposal Selection, allocation, preparation and equipment of land should start during month 1, also ordering equipment. Seed collection and purchase will start not later than month 5.	
Not before 6	Plantation Should start as soon as seedlings are available from the nurseries; one of the points to be clarified is how long the seedlings have to stay in the nursery, at which age (or which size) they are transplanted with the best chances of success. The land where plantations will be made should be selected during month 1, at the same time as selection of land for establishment of nurseries and live collections. Recruitment and training of watchmen should precede the plantation.	
Not before 6	Vegetative multiplication trials May start at any time from the beginning of the establishment of live collection phase.	
Around 10	Beginning of the observations on the collections.	
18	First Interim reports by participating institutions.	
30	Mid-term evaluation seminar, with reports of activities by participating institutions.	
32	Interim report by the coordinator of the project.	
55	Report of activities by participating institutions.	
57	Preparation of final report by coordinator.	
58	Revision of final report draft by participating institutions and donors.	
59	Editing of final report by backstopping institution.	
60	Printing and distribution of final report.	

RESEARCH COMPONENT A.1 BUDGET (for 5 years)

(The project is planned for three participating research institutions, in addition of the backstopping institutions).

	USD
Part-time coordinator (2m/m x 4 yrs plus 4m/m the first year)	40,000
2 research workers for 6 months (12m/m)	24,000
one bilingual secretary for 2 months	2,000
contribution to the scientific staff of the main backstopping organization (including editing of the report)	12,000
contribution of the scientific staff of other backstopping organization	4,000
animal nutrition consultancy (1m/m)	9,000
consultant to prepare agroforestry research programme (1m/m)	9,000
travel for 2 research workers (and per diem)	12,000
travel for animal nutrition consultant	3,000
travel for agroforestry research consultant	3,000
exchange of research workers between the 3 participating institutions	24,000
travel for coordinator	15,000
organization of a seminar to adopt the agroforestry research programme	45,000
at mid-term of the project seminar to evaluate the project, organized by the backstopping institution	50,000
secretariat expenses (salary excluded) for research workers	2,500
secretarial assistance to the coordinator (1500 x 5)	7,500
computerized research by backstopping institution	6,000
printing and distribution of the first 100 copies of the final report	4,500
seed collection, manipulation and storage (4000 x 3)	12,000
contribution to nursery equipment (2000 x 3)	6,000
selection and preparation of land to establish live collections of Capparaceae (5000 $ for each of the three institutions)	15,000
equipment for vegetative propagation trials (1500 x 3)	4,500
trials on vegetative propagation (5000 x 3)	15,000
equipment for monitoring (30,000 x 3)	90,000
trials on planting and protection (2,000 x 3)	6,000
studies on browsing and management (3,000 x 3)	9,000
dissemination of information	11,000
	441,000
+ 10% contingencies	44,000
	485,000

ANNUAL BUDGETS RESEARCH COMPONENT A.1

The various expenses are mentioned hereunder in the same order as the above budget.

Annual Budget allocations

	1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
Part time coordinator	13,336	6,666	6,666	6,666	6,666
Two research workers	24,000				
Bilingual secretary	2,000				
Backstopping organization costs	10,000	500	500	500	500
Other backstopping organization	4,000				
Animal nutrition consultancy	9,000				
Agroforestry research consultancy	9,000				
Travel for 2 research workers	12,000				
Travel for animal nutr. consult.	3,000				
Travel for AF research consult.	3,000				
Exchange of research workers		6,000	12,000	6,000	
Travel for coordinator	3,000	3,000	3,000	1,500	4,500
First seminar	45,000				
Mid-term seminar			50,000		
Secretariat research workers	2,500				
Secretariat coordinator	2,500	500	1,500	500	2,500
Computerized research	2,000	1,000	1,000	1,000	1,000
Printing final report					4,500
Seed collection	4,000	8,000			
Nursery equipment	2,000	4,000			
Live collection establishment	7,500	7,500			
Equipment vegetative propagation	1,500	3,000			
Trials on vegetative propagation		7,500	7,500		
Equipment for monitoring	35,000	35,000	10,000	10,000	
Trials planting and protection	4,000	2,000			
Studies browsing and management		4,500	4,500		
Dissemination of information			2,000	2,000	7,000
	198,336	89,166	98,666	28,166	26,666

RESEARCH COMPONENT A.2 - THE USE OF THE GENUS ATRIPLEX IN ARID ZONES

Most of the content of this chapter relies on a draft proposal presented by Dr. H.N. Le Houerou, co-author with A. Franclet of "Atriplex in Tunisia and North Africa" published in 1971 by F.A.O.

Background and rationale

There are about 300 species of Atriplex in the various arid zones of the world. Some 50 of them have an actual or potential use as browse and or utilization in revegetation programmes and in programmes to combat desertification.

The genuine interest shown in saltbushes in various arid countries of the world for the past 10 to 20 years is justified by their ecological and economical attributes.

1. They are extremely drought tolerant, growing as they do under annual mean rainfalls as low as 100 mm, and sometimes less.
2. They may tolerate salinity to a level comparable to the concentration of sea water.
3. Most species of Atriplex, contrary to many other arid zone shrubs, are adapted to clay soils.
4. Most species have a good to high feed value for herbivores with a medium to high protein content in the leaves and may thus play an important role as emergency feed in time of drought.
5. Water use efficiency is high since the most efficient species can product 1 kg of aerial DM out of 250 kg of water.
6. Tolerance to water stress is extremely high (F 5 and above)
7. Several species of Atriplex are being actually used in revegetation programmes in various arid zones of the world: USA, Australia, S. Africa, N. Africa, S. America, Near and Middle East, either as fodder shrubs, protection against soil erosion, reclamation of more waste, landscaping, amenity and wildlife management.

But failures are sometimes observed in the use of saltbushes due to insufficient knowledge of their biology, genetic diversity and economic potential.

Most species are constituted of genetically heterogeneous populations having different attributes of economic significance; moreover in virtually all populations there are individual shrubs with very significantly different economic potential such as palatial, leaf/stem ratio, productivity, drought tolerance, etc.

Scope of the project

1. To identify individual strains of known ecological provenance and adaptation (for instance in A. canescens there are populations growing on sand dunes, others on dry marls, on water-logged clays etc.; diploid, tetraploid, hexaploid, octoploid,

decaploid, dodecaploid populations are known to exist). Some populations grow below 20° latitude while others are found up to 55° latitude.

2. Cultivate various provenances of a small number of species of recognized economic value (A. nummularia, A. canescens, A. Halimus, A. undulata, A. amnicola, A. lentiformis, A. barclayana, A. glauca, A. paludosa, A. semi-baccata, A. stacemensis, A. repanda, A. vesicaria etc.) under similar ecological conditions under various climates and soils and test their ecological adaptation and their attributes of economic significance (wood production, fodder production, palatability to herbivores, etc.).

3. Select populations and individual shrubs within populations for their desired attributes and multiply them by cloning. This will have to be done in correlation with Project on Vegetative multiplication.

4. Store and make available to research organizations throughout the world plant material of known and tested genetic attributes (seeds and plantlets from vegetative multiplication, where appropriate). This will have to be done in correlation with Project on Vegetative multiplication.

Activities

1. Identify three research organizations interested to participate in the Research component.
2. Hire a small coordinator team; one qualified professional, one junior professional, one secretary.
3. Set up final project document with a programme of plant exploration, plant introduction and multilocal trials on a standardized basis; workshop to finalize and approve research component project document.
4. Appoint a governing body in charge of general guidance, assessment of progress and planning future activities.
5. Appoint an international organization for the overall backstopping and operation of the project.
6. Acquiring necessary equipment.
7. Plant exploration and introduction.
8. Multilocal trials.
9. Seminar to evaluate the results.
10. Final report and dissemination of the results.

Proposed duration: 3 1/2 years

Proposed Schedule

Activity	Year 1	Year 2	Year 3	Year 4
1	_ (2)			
2	_ (5)			
3	______(10)			
4	.... __(10)	_(12)		__
5	..... _(5)			
6		______(2)		
7	_________________(6)..........................			
8		... _____(6)..		
9				__(2)
10				___(6)

RESEARCH COMPONENT A.2. BUDGET

One professional (forester, range management specialist, or agronomist) (42 m/m)	175,000
One junior professional (36 m/m)	108,000
One secretary	42,000
Travels for professionals	30,000
Consultations of non-participating research institutions	15,000
Computerized research by the backstopping organization	7,000
Equipment for three participating organizations	90,000
Plant exploration and acquisition	15,000
Multilocal trials	30,000
Meetings of governing body	30,000
Overall backstopping	31,500
Seminar to evaluate the results	40,000
Final report preparation, editing and printing (100 copies)	5,000
	618,500
+ 10% contingencies	61,850
	680,350

ANNUAL BUDGETS

The various expenses are mentioned hereunder in the same order as the above budget.

	Year 1	Year 2	Year 3	Year 4 (6 months)
Professional	50,000	50,000	50,000	25,000
Junior professional	18,000	36,000	36,000	18,000
Secretary	12,000	12,000	12,000	6,000
Travels	8,000	10,000	8,000	4,000
Consultations	4,000	6,000	5,000	
Computerized research	3,000	2,000	1,000	1,000
Equipment	35,000	50,000	5,000	
Plant exploration and acquisition	5,000	5,000	5,000	
Multilocal trials	10,000	10,000	10,000	
Meetings of governing body	10,000	10,000		10,000
Overall backstopping	9,000	8,000	8,000	6,500
Seminar			5,000	35,000
Final report				5,000
	164,000	199,000	145,000	110,500

RESEARCH COMPONENT A.3 - CACTACEAE IN AGROFORESTRY

This chapter is largely based on a contribution of Dr. H.N. Le Houerou (C.N.R.S., France) and on the work of P. Felker and C.E. Russel, (Texas A & I University).

Background and rationale

There are approximately 130 genera with about 300 species in the only genus Opuntia; a number of these are used as fodder for livestock and wildlife and as food for humans. As fodder, cactus is unbalanced being low in proteins and lipids but rich in digestible carbohydrates, water and vitamins. As wrote Russell "it is perhaps fortunate that cactus is low in protein, otherwise, its leverage of water to dry matter production would be nitrogen-limited".

Fodder and fruit cacti are cultivated in a number of countries in the arid zones, sometimes with extremely high yields, since harvests of 20,000 to 30,000 kg of fodder DM per ha/yr have been reported in several countries under arid and semi-arid rainfed conditions. (In Mexico, Riquelme reported 400 t/ha/yr of freshweight, equivalent to 52 t/ha/yr of fodder DM).

However, there are a number of problems to be solved before cacti may be extended to some arid zones having cool or cold winters, and low atmospheric humidity for extended periods.

Scope of the project

Objective:
To identify provenances and/or cultivars of cacti adapted to various environmental conditions within the arid zone, particularly to areas with cold winters.

Activities:

1. Set up a germplasm of fodder and fruit "varieties" (there are for instance some 20 empiric "cultivars" of fruit cacti (O. ficus-indica) in Sicily which have never been experimentally studied. There are a number of species with a high fodder potential that are being used in various countries (O. Ficus-indica, O. robusta, O. fusicaulis, O. streptacantha, O. lindheimeri, O. ellisiana, O. stricta, O. inermis, O. leptocaulis, O. undulata, O. maxima, O. Engelmanii.

2. Compare various cultivars and provenances for productivity, cold tolerance, fruit production and quality under standardized ecological conditions in a number of sites, in different ecological arid zones of Africa, Asia and America.

3. Select well adapted and productive species, provenances and cultivars for the various ecological regions tested.

4. Make available to interested research organizations selected material of known performance, in small quantities.

Follow-up

In a phase 2: Identify ways and means to manage Cactaceae as "food providers" and "emergency drought fodder", rather than as potentially "noxious weeds".

Project development

1. Appoint an international organization responsible for the implementation of the project.
2. Hire a project team: a senior professional, a junior professional and a secretary.
3. Identify participating research organizations and establish a network of experimental sites.
4. Nominate a governing body in charge of general guidance, assessment of progress and planning future activities.
5. Collect plant material and set up the "cacteta" in the selected sites.
6. Evaluate the performance of the various species, provenances and cultivars in each site.
7. Select and propagate the best performers in the desired attributes.
8. Multiply and make available small quantities of material in the successful accessions to interested parties.
9. Convene periodical meetings with interested parties in order to evaluate results and plan future activities.

PROPOSED SCHEDULE

	Year 1	Year 2	Year 3	Year 4
Recruitment of project team	___(4)			
Identification of backstopping org.	___(3)			
Identification of cooperating inst.	(1)____(6)			
Governing body	(4)_ (5)		(2)_(3)	(9)_(10)
Preparation of project document and research protocols	(4)_____(10)			
consultations	(5)....(8)			
Selection of research sites	(10)____(1)			
Collection of plant material	(6)________(1)			
and establishment of cacteta	(10)____(2)			
Evaluation of performances	(10).......(2)	____________________	(2)..>	
Selection of propagation of best performers			(2)............................	(2)__(8)
Multiplication of best accessions				(2).....(8)___>
Visits by scientists from				(4)...(6)__(8)
non-participating institutions				
Final report				(8)...(10)_(12)

RESEARCH COMPONENT A.3 BUDGET

NB. the budget has been calculated for three participating research organizations.

	USD
Coordinator (36 m/m; half-time during years 2 and 3)	150,000
Junior professional (36 m/m)	108,000
Secretary (48 m/m)	48,000
Travels for professionals	30,000
Computerized research by backstopping organizations	4,000
Equipment for three participating organizations	15,000
Plant exploration and acquisition	5,000
Consultations for preparing research protocols	4,000
Selection and equipment of research sites and cacteta	12,000
Evaluation of performances	10,000
Meetings of governing body	24,000
Multiplication and delivery of best accessions	15,000
Visits of scientists from non-participating institutions	20,000
Preparation, editing and printing 100 copies of final report	5,000
	450,000
+ 10% contingencies	45,000
	495,000

RESEARCH COMPONENT A.3 - ANNUAL BUDGETS

	Year 1	Year 2	Year 3	Year 4
Coordinator	50,000	25,000	25,000	50,000
Junior professional	18,000	36,000	36,000	18,000
Secretary	12,000	12,000	12,000	12,000
Travels	10,000	10,000	5,000	5,000
Computerized research	4,000			
Equipment	15,000			
Plant exploration and acquisition	5,000			
	4,000			
Research sites and cacteta	6,000	6,000		
Evaluation		5,000	5,000	
Governing body	7,000		8,000	9,000
Multiplication & delivery of accessions			5,000	10,000
Visits of scientists			10,000	10,000
Final report				5,000
	131,000	94,000	106,000	119,000

Background reading

Monjauze A. & H.N. Le Houérou., 1965: Le rôle des Opuntia dans l'économie agricole de l'Afrique du nord. Bull. École. Nat. Sup. Agr. Tunis, 8-9:85-164.

Riquelme, V. - 1984. (reported in Russell and Felker, 1985a).

Russell C.E., 1985 - Cactus, ecology and range management during drought. Livestock and Wildlife Management during drought, Proc. of a Workshop, Texas, A& I Univ., 19 June, 1985.

Russell, C.E. et P. Felker - 1985a - The prickly pears: promising crops and forage plants for arid and semi-arid regions. Kingsville, Texas A & I University.

Russell, C.E. & P. Felker, 1985b - Opuntia species. Plantas con potencial economico. IX World Forestry Congress, Saltillo, Cahuila, Mexico.

PROJECT B - AGROFORESTRY MANAGEMENT FOR FODDER IN DRY ZONES

Background

In the dry zones of Africa especially with a monomodal regime of rains one of the most crucial constraints in the frequent lack of fodder during the end of the dry season. There is an insufficient quantity of fodder and a decrease in the quality also. But many woody perennials provide fodder during that critical period ("période de soudure" as it is called in French) and that fodder produced by some species is of good quality. It is believed that the multiplication of these species, especially in various agroforestry systems, could help greatly in alleviating the shortage of forage.

Four research components are proposed hereunder:

B.1. The management of hedges to produce fodder.

B.2. The management of trees for fodder production.

B.3. Fodder productivity and quality of selected browse species.

B.4. Phenology and physiology of leaf growth.

It is repeated here that other combinations of these research components could be made, and that other research components could be added. The present choice was dictated by the desire:

i) to present components not too expensive for a single donor

ii) to divide the project in order to make its monitoring easier

iii) to give priority to research fields which were considered as important during the IUFRO Workshop in Nairobi or during previous conferences, seminars and workshops.

RESEARCH COMPONENT B.1 - THE MANAGEMENT OF HEDGES TO PRODUCE FODDER

Objectives

To collect and disseminate information on beneficial associations of woody plants in productive hedges, with the object of developing fodder production and to establish designs and management procedures for their use.

Activities

1. Appoint a part-time coordinator, designate a backstopping institution and identify three participating institutions.
2. The coordinator and backstopping institution would prepare protocols and define the methodology and programme for collecting information on hedges and their products, especially fodder.
3. Collect, analyze and publish the available information including the role of environmental factors.
4. Based on these studies, establish models of mixed hedges to be tested.
5. Each of the participating institutions would establish a set of models to test their productivity.
6. Visit of the coordinator to the participating institutions.
7. Preparation of interim reports by the institutions.
8. Workshop on hedge productivity.
9. Continuation of the experimentation by the institutions and production of reports.
10. Final report of the coordinator with recommendations.

Inputs required

1. The coordinator could be recruited part-time, with the following schedule:

   year 1:
      design of work programmes with the backstopping institutions: 6 weeks
      development of models with the backstopping institution: 8 weeks

   year 2-3:
      visits to participating institutions (5 institutions presumed): 5 weeks

   year 3-4:
      preparation, participation and proceedings of the workshop: 16 weeks

   year 5:
      preparation of the final report: 8 weeks.

2. The backstopping institution would provide constant support to the coordinator, as well as technical, secretarial help, and would take a large part in the design of the work programmes, in the preparation of models, in visiting participating institutions, in the workshop and in the final report.

3. Technical and financial support (equipment, seeds, field subsistence allowances etc.) to the participating institutions. Equipment may include: measuring and

survey equipment, drying oven, weighing scales, sampling bags, labels, markers, etc.

4. Organization by the backstopping institution with the coordinator of a workshop on hedge productivity.

5. Clerical assistance to the coordinator (43 weeks).

Proposed duration: 5 years

Months	
0 - 1	Appointment of the coordinator and designation of the backstopping agency.
1 - 3	Preparation of the work programmes Ordering equipment
4	Initiation of data collection on hedges and their products by participating institutions
10	Reports by participating institutions on collection and analysis of data
11 - 12	Preparation of experimental models
13 - 14	Establishment of models by participating institutions
15 - 37	Monitoring the models by participating institutions
23 - 24	Visits to participating institutions
34 - 35	Interim reports by participating institutions
37 - 41	Preparation of the workshop, workshop report
55 - 58	Production of reports by institutions
59 - 60	Final report and recommendations

RESEARCH COMPONENT B.1 BUDGET

		$
Coordinator for 43 weeks (over 5 years)		64,000
Travel		8,000
Subsistence allowances		19,500
Equipment	5000 x 3	15,000
Seeds	1000 x 3	3,000
Contributions to field subsistence allowances of the 5 institutions for 50 days/year 40 x 50 x 3 x 5		30,000
Workshop		70,000
Backstopping institution (equivalent 3 m.m.)		28,500
Secretariat		5,000
Final report editing and typing		3,000
		246,000
+ 10% contingencies		24,600
		270,600

ANNUAL BUDGETS

	Year 1	Year 2	Year 3	Year 4	Year 5
Coordinator	29,800	10,700	16,500	17,500	17,000
Equipment	12,000	3,000			
Seeds	3,000				
Field allowances	6,000	7,000	6,000	6,000	5,000
Workshop			20,000	50,000	
Backstopping institution	6,700	6,000	5,400	4,400	6,000
Secretariat	1,200	1,000	500	1,000	1,300
Final report					3,000
	58,700	27,700	48,400	78,900	32,300

RESEARCH COMPONENT B.2 - THE MANAGEMENT OF TREES FOR FODDER PRODUCTION

Objectives

To collect and disseminate information on the management of browse, to investigate ways to improve it, such as methods of cutting branches (lopping, pollarding, etc) to obtain a high and sustainable yield of fodder, and to examine the relationship of the production of fodder with other products.

Activities

Research will be limited to a few species and a limited number of ecosystems. It is suggested three institutions participate plus one backstopping organization.

1. Recruitment of a part-time coordinator, choice of participating and backstopping institution. (months 1-4)
2. Establishment of research designs and programmes by a backstopping agency with the cooperation of a representative of each of the three implementing institutions. (months 5-6)
3. Provision of standard eqiupment to the four institutions. (months 2-8)
4. Implementation of the programmes by the institutions. (months 7-60)
5. Interim report by the four institutions. (15) and by the coordinator (17)
6. Mid-term report after 33 months by the four institutions. (33) and by the coordinator (35)
7. Final report and recommendations by the backstopping agency in collaborative with the implementing institutions.

Inputs required

1. Workshop to prepare the research programmes. (5)
2. Equipment for each participating institution. (2-8)
3. Financial support to participating institutions. (7-60)
4. Exchange of scientists.
5. Support for the preparation of final report and recommendations. (57-60)

Proposed duration: 5 years
Schedule for the coordinator (43 weeks over 5 years)

Year 1:	preparation of work programme with backstopping institutions, selecting and ordering equipment, visit to the three participating institutions (14 weeks).
Year 2:	visiting three participating institutions, and providing interim report (8 weeks).
Year 3:	mid-term report, preparing exchanges of scientists (7 weeks).
Year 4:	visiting three participating institutions, exchange of scientists (6 weeks).
Year 5:	final report (8 weeks).

RESEARCH COMPONENT B.2. BUDGET

Part-time coordinator (43 weeks over 5 years)	64,000
Travel	14,000
Subsistence allowances	21,500
Workshop to prepare research programme	
Travel 1200 x 4 (3 institutions + 1 donor)	4,800
Subsistence allowance 70 x 7 x 4	1,960
Backstopping agency 220 x 7 x 2	3,080
Secretariat	200
Equipment for each participating institution	
Vehicle 10,000 x 3	30,000
Contribution to maintenance of vehicles 5000 x 3 x 5	75,000
Measuring and scientific equipment 6000 x 3	18,000
Other equipment 2000 x 3	6,000
Acquisition of plant material 1500 x 3	4,500
Contribution to field all. for participating institutions	
60 days/year/3 institutions/5 year: 40 x 60 x 3 x 5	36,000
Lump sum as a contribution to reports: 500 x 3 x 3	4,500
Interim report of the coordinator and distribution	1,500
Report by the coordinator after 33 months and distribution	1,500
Exchange of scientists between participating institutions	20,000
Visits of other scientists to participating and/or backstopping institution	20,000
Preparation of the final report, editing and typing by the backstopping institution and printing of 100 copies	4,500
	331,040
+ 10% contingencies	33,104
	364,144

RESEARCH COMPONENT B.2. ANNUAL BUDGETS

	Year 1	Year 2	Year 3	Year 4	Year 5
Coordinator	20,900	11,900	10,400	8,900	11,900
Travel	5,000	2,000	2,000	3,000	2,000
Subsistence allowance	6,500	3,500	3,500	4,500	3,500
Preparatory workshop					
Travel	4,800				
Subsistence allowance	1,960				
Backstopping agency	3,080				
Secretariat	200				
Equipment					
Vehicle	20,000	10,000			
Maintenance	10,000	20,000	15,000	15,000	15,000
Scientific equipment	9,000	9,000			
Other equipment	3,000	3,000			
Plant material	2,500	2,000			
Field allowances	7,200	7,600	7,200	7,000	7,000
Contribution		1,500	1,500		1,500
Interim report		1,500			
Mid-term report			1,500		
Exchange scientists		10,000	10,000		
Visits by scientists			5,000	10,000	5,000
Final report					4,500
	94,140	82,000	56,100	48,400	50,400

RESEARCH COMPONENT B.3 - FODDER PRODUCTIVITY AND QUALITY OF SELECTION BROWSE SPECIES

Objectives

To collect and disseminate information on the direct and indirect productivity of some of the more important browse species under different systems of management. The establishment of suitable management rules for these species for land use planning and the estimation of their productivity on range lands.

Observations

It is proposed the direct fodder productivity of twenty browse species would be measured. Productivity and its variability would be evaluated at the level of the tree, at the specific level, at subregional level, and at global level. Studies would be made on isolated trees, and in various pure and mixed associations. In Phase 1, it will probably not be possible to collect data other than on isolated trees; the plantations will have to be initiated during Phase 1 which is initially planned for three years, although many more years would be needed to obtain a complete range of results.

The impact of browse species on herbaceous fodder production would also be measured, taking into account the role of various environmental factors.

Some coordination would be advisable with Research component B.2 "The management of trees for fodder production".

It is expected that five institutions plus a backstopping one would participate.

Activities

1. Identification of the backstopping organization, and recruitment of a part-time coordinator.
2. The backstopping organization prepares research plans and submits them to participating organizations for revision and approval during a workshop.
3. Provision of standard equipment to the five participating institutions.
4. Preparation of a state-of-knowledge report on the fodder productivity of browse species and the design of a research project on browse appetability and nutritional value; this activity would be developed jointly with activity 2 of Research Component A.1, under the responsibility of the backstopping organization.
5. Field visits by the coordinator.
6. Interim reports by participating institutions.
7. Final reports by participating institutions.
8. Synthesis report by the coordinator, and preparation of a follow-up project.
9. Exchange of scientists.

Inputs required

1. Recruitment of a part-time coordinator to work on preparation of research plans and monitoring and evaluation procedures.

2. Organization of a workshop to prepare and adopt the research plans, with one representative from each of the five participating institutions, representatives of donors, of the backstopping institution, and observers.
3. Equipment to be provided when needed to the five participating institutions. This would include: measuring instruments survey and, meteorological equipment, photographic equipment, tools and chemicals.
4. Field expenses of the institutions.
5. Secretarial support for the coordinator.
6. Travel and daily subsistence allowances.
7. Exchange of scientists. If we suppose that, geographically, the participating institutions are in a sequence A,B,C...z, it is suggested the first field visit of the coordinator will be made to institutions A, C, E, G............. and that when he visits A, a scientist from B is invited to participate.

   When he visits C, a scientist from D is invited to participate etc.
   During the second field tour, the coordinator will visit
      B where he will be joined by a scientist from A
      D where he will be joined by a scientist from C
      F where he will be joined by a scientist from E, etc.

8. Contribution to the cost of establishment of interim and final reports by participating institutions.
9. Participation of the backstopping organization.

Proposed schedule (in months)

0 - 1	Nomination of the part-time coordinator (22 weeks in 3 years)
1 - 2	First draft of research programme
3	Workshop (3 days). Ordering equipment
4	Report on the workshop by the coordinator, and published by the backstopping organization
5 - 33	Field work by participating institutions
5	Preparation by the coordinator (in liaison with Research Components A.1. and B.2. of a research proposal on appetability and nutritive value of browse
6 - 7	First field tour by the coordinator, accompanied, by a scientist from another institution
8 - 9	Report on the first field tour prepared by coordinator and published by the backstopping organization
10 - 13	Status of knowledge report prepared by the coordinator
14	Editing the status of knowledge report (no activity for coordinator in months 15-20)
19	Interim reports from the participating institutions
21 - 22	Synthesis of the interim reports by the coordinator and publication of a global interim report by the coordinator with assistance of backstopping organization
23 - 24	Second field tour by the coordinator, accompanied by a scientist from another institution
25 - 26	Report on the second field tour prepared by coordinator and published by the backstopping organization, and draft proposals for follow-up No activity for the coordinator in months 27-34

34 Final report of participating institutions
35 - 36 Final report by the coordinator, published by backstopping organization, and workshop to discuss proposals for follow-up

Duration: 3 years.

RESEARCH COMPONENT B.3. BUDGET

Coordinator	160,000
Travel	12,000
Subsistence allowance	40,000
Workshop to prepare detailed programme	
Travel	5,000
Participating of FAO and ILCA (air-tickets)	1,800
Subsistence allowance 60 x 7 x 4	1,680
Backstopping organization	6,000
Equipment: 8000 x 5	40,000
Secretarial assistance to the coordinator	15,000
Lump sum to participating institutions for	
interim reports 500 x 5	2,500
for final reports 1000 x 5	5,000
Exchange of scientists for 2 weeks each	
Travel	5,000
Subsistence 60 x 14 x 5	4,200
Contribution to field allowances for participating institutions 60 days/$40/3 years 60 x 40 x 3 x 5	36,000
Support to backstopping organization	18,000
	352,180
+ 10% contingencies	35,218
	387,398

RESEARCH COMPONENT B.3. ANNUAL BUDGET

	Year 1	Year 2	Year 3
Coordinator (with travel and subsistence allowance)	130,000	55,000	27,000
Workshop	14,480		
Equipment	30,000	10,000	
Secretariat	8,000	3,000	4,000
Interim report		2,500	
Final report			5,000
Exchange of scientists	4,600	4,600	
Field allowances	10,000	14,000	12,000
Backstopping organization	8,000	4,000	6,000
	205,080	93,100	54,000

RESEARCH COMPONENT B.4 - PHENOLOGY AND PHYSIOLOGY OF LEAF GROWTH

Objectives

To collect, disseminate, and to improve the knowledge on phenology of woody species and on the physiological processes which control the flushing and fall of leaves, with a view to improving field management.

1. This is conceived as a fodder project but could also serve other purposes: for example, there are leaves used as food (especially young leaves).
2. It is suggested that three institutions work on this project, for which Phase 1 only is proposed here.

Activities

1. Designation of a part-time coordinator
2. First workshop organized by the backstopping institution to prepare research plans for Phase 1 and identify and priorities genera and species to be studied
3. Acquisition of equipment for the three participating institutions
4. Initiation of field work: surveys of tree populations to select individuals - which we call "select early" - and possibly also populations, which produce leaves earlier, marking and protecting these plants, collecting seeds and cuttings for vegetative propagation and creating propagation orchards of selected phenotypes for mass selection
5. Similar work on individuals that keep their leaves longer. These individuals will be called "select late"
6. Exchange of plant material between participating institutions
7. On fully protected trees in the field, trials of various hormones to accelerate or delay the formation of leaves
8. Similar experiments on young seedlings cultivated in vitro and in nurseries or special plots
9. Visit of the coordinator to the participating institutions
10. Preparation by the coordinator of a project document for Phase 2 (on the physiological processes and genetics which control early flushing or late fall of leaves)
11. A one-year fellowship on vegetative multiplication, tissue culture, and meristem multiplication
12. Three six-months fellowships on hormones and auxins
13. In the last third of Phase 1, a second workshop, in one of the participating institutions (or in the country where this institution is located), or in the backstopping institution, would be held to evaluate the first results obtained, to exchange views, to discuss and finalize proposals for Phase 2.
14. Preparation by the coordinator of the final report of Phase 1.
15. Financial and technical support to the participating institutions

NB - It is recommended that the coordinator be a plant physiologist, and the backstopping institution be an institution suitably equipped and competent in this field.

Proposed schedule (in months)

0 - 1	Recruitment of part-time coordinator and of a backstopping institution
1 - 2	Preparation of the first workshop. Ordering equipment
3	Workshop 1 (4 days), development of research plans choice of species. Beginning of the four fellowships (commencement probably dictated by academic timetables)
4	Initiation of field work
7	Visit of the coordinator to participating institutions for backstopping
4 - 10	Three short term fellowships
12	First interim report produced by each of the three participating institutions, with the cooperation of the recently-returned fellows
13	Interim reports circulated by the coordinator with a synthesis
18	Second interim report produced by each of the three participating institutions and circulated
4 - 16	End of the long term fellowship
21	Workshop 2 (4 days) with participation of the long-term fellow, the three short-term fellows, the coordinator, the appropriate research workers in each of the participating institutions, with invited participants and observers for evaluation and preparation of follow-up
24	Final report of Phase 1 by the coordinator

Duration 24 months

Follow-up

Phase 2 could include:

a) continuation of research initiated in Phase 1; monitoring the orchard of "plus" trees

b) research on physiological and genetical processes involved in leaf and fruit formation and leaf and fruit fall, on trees and shrubs producing leaves and fruits used as fodder, and possibly in addition as food (such as *Adansonia digitata* or *Moringa oleifera* for leaves, *Butyrospermum Parkii* or *Balanites aegyptiaca* for fruits).

RESEARCH COMPONENT B.4. BUDGET

Coordinator: 3 weeks to prepare workshop I initially
3 weeks for field visits
1 1/2 week for analyzing and commenting on first interim reports
2 1/2 weeks for preparing project document for Phase 2
5 weeks for Workshop II, including writing and editing final report, and 2 weeks field visits

a total of 15 weeks	30,000
travel	5,000
Subsistence allowance 60 x 35	2,100
Workshop I	
travel for 3 participants	3,600
subsistence allowance 80 x 5 x 3	1,200
documentation	1,000
organization and secretariat	1,400
Support to participating institutions for three reports 500 x 3 x 3	4,500
Secretarial assistance to coordinator	4,000
Fellowship for one year	24,000
3 Fellowships for six months	36,000
Workshop II	
Travel: 3 institutions + 4 fellows + 2 invited guests	9,000
Subsistence allowances for 9 people for 7 days 80 x 9 x 7	5,040
Documentation	2,000
Organization and secretariat	2,000
Assistance to participating institutions for field work: 60 x 100 x 3	18,000
Equipment: 6000 x 3	18,000
Contribution to project vehicle maintenance 3000 x 3 x 3	27,000
Books and documentation: 2000 x 3	6,000
	199,840
+ 10% contingencies	19,984
	219,824

RESEARCH COMPONENT B.4. ANNUAL BUDGETS

	Year 1	Year 2	Year 3
Coordinator	15,000	4,100	18,000
Workshop 1	7,200		
Support for reports	1,500	1,500	1,500
Secretariat	1,500	1,000	1,500
Fellowship one year x 1	18,000	6,000	
Fellowships three months x 3	36,000		
Workshop			18,040
Assistance for field work	4,000	7,000	7,000
Equipment	12,000	6,000	
Contribution to vehicle maintenance	7,000	10,000	10,000
Books and documentation	4,000	2,000	
	106,200	37,600	56,040

PROJECT C - AGROFORESTRY MANAGEMENT FOR FUELWOOD AND FODDER PRODUCTION IN DRY ZONES

Background

The main emphasis of this project is the production of fuelwood of which there is a national shortage in most of the dry countries of Africa. As noted previously, the production of fuelwood only, in woodlots, does not meet the identified needs of most of the rural inhabitants and therefore it is necessary to examine fuelwood production in conjunction with other land uses, as well as examining the use of marginal lands for this purpose.

The three research components in this project are

C.1 The productivity of windbreaks
C.2 Productivity in Saline Lands
C.3 Fuelwood productivity in various agroforestry systems.

The rationale behind this is, specifically, to evaluate productivity in existing situations where windbreaks/shelterbelts are used, against environmental and design aspects. This is a clear-cut research situation. The evaluation of saline lands is an attempt to bring very large areas of currently unproductive land into production, and the final component is intended to cover existing and developing agroforestry situations from the point of view of mainly fuelwood production. In this last component, the productivity of trees grown as individuals rather than in closed stands is the main study area.

RESEARCH COMPONENT C.1 - PRODUCTIVITY OF WINDBREAKS

Objectives

To carry out a global evaluation of the impact of windbreaks, to assess their productive potential for fuelwood and other products and to develop management methods to optimize fuelwood production without reducing the environmental benefits, and to disseminate the information obtained.

Linkages: Project D, Component D.2.

Activities

1. Collect and analyze information on the production of fuelwood and other products in windbreaks.
2. Establish various models of windbreaks to test their productivity. Utilization of simple or composite structures (one or several rows, one or several layers) with mono - or multispecific windbreaks. Assess the impact of these models on the productivity of the protected field or fodder crops.

Inputs required

1. Recruitment for six months of a research officer to prepare a report on fuelwood production in windbreaks.
2. Preparation by a consultant of a research programme, with detailed plans for the following situations:
    - irrigated cropping
    - rainfed cropping (with and without animals)
    - extensive animal husbandry.
3. One 2-months fellowship for each of the three institutions proposed for participation in the Project.
4. Technical backstopping to the institutions participating in the Project.
5. Provision of measuring, meteorological and other equipment to the institutions.
6. Evaluation of the wood produced, including calorific values to be conducted in laboratories in participating countries.
7. Workshop on scientific aspects of windbreaks.

Proposed schedule (in months)

0 - 6	Report on fuelwood production in windbreaks by research consultant
2	Preparation of the detailed plans (consultant for six weeks, with visits to the research officer, to the 3 participating institutions, and to ICRAF)
3 - 4	Ordering equipment, following recommendations of the consultant.
5 - 6	three 2-month fellowships
7 - 19	Measuring production in existing windbreaks and establishment of different windbreak models
19	The 3 participating institutions produce interim reports
20 - 36	Continuation of the activities of the participating institutions
21	Visit to the institution by a consultant for backstopping
24	Workshop
34	The 3 participating institutions produce final reports

35 The consultant produces a global report with recommendations for follow-up

36 Consultations between donors, representatives of the participating institutions, and the consultant, for follow-up.

Duration 3 years.

COMPONENT C.1. BUDGET

1. Contribution by the donor to each of the 3 participating institutions: laboratory facilities, salaries of 1 research worker, labourers, driver, secretarial support, expenses for communication, reimbursement on justification:		
3 x 60,000 for 3 years		180,000
2. Fellowship 6 months		12,000
Subsistence allowance		7,000
Travel		2,500
Consultant: six weeks to prepare research plans		10,500
travel		2,500
Subsistence allowance 30 days		1,800
1 month of backstopping		7,000
travel		2,500
Subsistence allowance 20 days		1,200
Final report writing		3,500
one week final consultation		1,750
Subsistence allowance 7 days		500
Three 2-months fellowships	8000 x 3	24,000
Subsistence allowances	60 x 60 x 3	10,800
Workshop		40,000
3 journeys for the final consultation (5 days)		4,500
Subsistence allowances	60 x 3 x 5	900
Equipment	4000 x 3	12,000
		324,950

RESEARCH COMPONENT C.1 - ANNUAL BUDGETS

	1st Year	2nd Year	3rd Year
Contributions to institutions	60,000	60,000	60,000
Fellowship (Research Officer)	12,000		
Subsistence & Travel	9,500		
Fellowships (2 month)	24,000		
Subsistence and travel	10,800		5,400
Equipment	12,000		
Consultant	10,500	7,000	5,250
Subsistence & Travel	4,300	3,700	500
Workshop		5,000	35,000
	143,100	75,700	106,150

RESEARCH COMPONENT C.2 - PRODUCTIVITY IN SALINE LANDS

Objectives

To collect and disseminate information on the productivity of saline lands and to design agroforestry systems to make them more productive of fodder and fuelwood.

Justification

The UNESCO soil map of Africa indicates that 3.5% of Africa or 9.86 million ha is affected by various forms of salinisation. About half of these areas are in the countries covered by the current IUFRO Workshop. The most affected country is Somalia.

Activities

It is proposed that an institution in each of three countries participate in the project, which would have the following activities:

1. 5 day workshop to prepare research plans under the guidance of a coordinator.
2. Survey of saline lands in each country.
3. Provision of plant material and equipment to the participating institutions.
4. Utilization of existing nurseries to produce seedlings.
5. Species and provenance trials as appropriate, using the lists in the Appendix.
6. Technical backstopping to the institutions by the coordinator.
7. Comparison of various technologies for the establishment of the species under trial, in one of the three institutions.
8. Study of the fodder and fuelwood productivity under different management regimes.
9. Impact of woody plants on the productivity of herbaceous cover; total fodder production studies.
10. Production of annual reports by concerned institutions.
11. Three fellowships of one-year duration on rehabilitation of saline lands.
12. One two-year fellowship for a M.Sc. in Soil Science, specializing in rehabilitation through vegetation.
13. Exchange of scientists between participating institutions.
14. Final report.

Inputs required

1. Part-time coordinator for 6 months over 3 years
2. Provision of soil analysis equipment, fencing materials, nursery equipment, vehicle (with maintenance and spare parts)
3. Fellowship costs
4. Travel and subsistence allowances
5. Support to the institutions to produce reports and to do field work.

Proposed schedule (months)

0 - 1	Recruitment of coordinator
1 - 2	Ordering equipment and preparing workshop
3	Workshop and beginning of two year fellowship

4	Beginning of six month fellowships
3 - 6	Initiation of field work: species and provenance trials
6	Visits of the coordinator to the three participating institutions
7	In one selected participating institution, initiation of comparisons of establishment technologies
10	End of one year fellowships
15	First annual reports
18	Second visit of the coordinator to the three participating institutions
21 - 22	Exchange of scientists
27	End of two year fellowship Second annual reports
30	Third visit of the coordinator to the three participating institutions
34	Final reports by participating institutions
36	Final report by the coordinator.

Duration 3 years.

Suggested species for trial on saline lands

a) trees

Azadirachta india, Anacardium occidentale, Acacia tortilis,* Casuarina equisetifolia, C. glauca, Mitragyne inermis,* Parkinsonia aculeata,* Prosopis cinerea,* P. juliflora,* P. Tamarugo,* Tamarix aphylla, T. gallica, T. senegalensis, Zizyphus mucronata,* Z. spina christi,* Melaleuca pauperiflora, M. quadrifaria.

b) Shrubs

Atriplex amnicola,* A. atacamensis,* A. barclayana,* A. canescens,* A. Halimus,* A. lentiformis,* A. linearis,* A. nummularia,* A. rhagodioides,* A. paludosa, A. repanda,* A. undulata,* A vesicaria,* Kochia indica,* Halosarcia,* Maireana brevifolia,* Enchylaena tomentosa,* Rhagodia,* Nitraria retusa,* Salsola,* Salvadora olioides,* S. persica,* Sesbania sesban,*

c) Eucalyptus spp. Eucalyptus dundassi, E. kondininensis, E. sargentii, E. torquata, E. brockwayi, E. campaspe, E. intertexta, E. longicornis, E. sideroxylon, E. stricklandii, E. platypus var. heterophylla, E. spathulata, E. occidentalis, E. camaldulensis, E. gracilis, E. grandis, E. lehmannii, E. microtheca, E. rudis, E. gomphocephala, E. polyanthemos, E. robusta, E. viminalis.

Species marked (*) may give fodder in addition to fuelwood.

d) grasses

Aeluropus, Cynodon dactylon, C. aethiopicus, Dactyloctenium aegyptium, D. geminatum, Distichilis spicata, Leptochloa, Panicum antidotale, P. repens, Paspalum vaginatum, Pennisetum americanum, P. clandestinum, Puccinellia ciliata, Sporobolus.

e) Legumes

Indigofera oblongifolia, Macroptilium atropurpureum, M. lathyroides, Medicago sativa, Trifolium alexandrinum.

RESEARCH COMPONENT C.2. BUDGET

Coordinator:	6 months		40,500
	Subsistence allowance	60 x 150	9,000
	travel		7,000
3 Fellowships @13,000			39,000
1 Fellowships			29,000
Equipment:	pedological and meteorological equipment		36,000
	nursery equipment: 20000 x 3		60,000
	fencing materials: 15000 x 3		45,000
	vehicle (with maintenance and spare parts): 30000 x 3		90,000
	Land preparation equipment for one institution		50,000
Assistance to 3 institutions for annual reports 500 x 3 x 3			4,500
Assistance for field work (90 days during 3 years) 60 x 90 x 3			16,200
Exchange of scientists			
	travel	1000 x 3	3,000
	subsistence allowance 60 x 15 x 3		2,700
Workshop			6,000
			437,900
	10% Contingencies		43,800
			481,700

RESEARCH COMPONENT C.2. ANNUAL BUDGETS

	1st Year	2nd Year	3rd Year
Coordinator 2 months/yr	13,500	13,500	13,500
Travel & subsistence	5,500	5,500	5,000
Equipment (vehicles) & maintenance	30,000	30,000	30,000
Equipment (land preparations) & maintenance	40,000	5,000	5,000
Fencing	20,000	25,000	
Equipment (meteorological etc)	36,000		
Nursery equipment	60,000		
Field work	5,400	5,400	5,400
Exchange of scientists		5,700	
Fellowships (6 months x 3)	39,000		
Fellowship (2 yr)	11,000	14,500	3,500
Annual report assistance	1,500	1,500	1,500
Workshop	6,000		
	267,900	106,100	63,900

RESEARCH COMPONENT C.3 - FUELWOOD PRODUCTIVITY IN VARIOUS AGROFORESTRY SYSTEMS

Objectives

To collect and disseminate information on fuelwood production of selected woody perennials in the following agroforestry systems: alley cropping, home gardens, farm woodlots, boundary planted and intercropped trees.

Activities

It is recommended that five institutions participate in this project, which would have the following activities:

1. Nomination of a coordinator
2. Workshop to develop research plans and to apportion responsibilities between participating institutions
3. Supply of equipment to the research institutions
4. Technical and financial backstopping to field work activities of the research institutions
5. Support for regular reporting by research institutions
6. Facilitating linkages between research institutions participating in the project and research institutions engaged in research on productivity of natural woody formations: this will be made through a visit by one research worker of each of the participating institutions to
    a) a recognized leading international institution working in that field (6 days)
    b) one of the other participating institutions, different for each visitor (2 weeks)
7. Funding for analysis by other institutions
8. Final report.

Inputs required

1. Consultant coordinator to prepare the workshop and to prepare research plans (2 1/2 months), to visit the participating institutions (5 weeks in first year plus 1 week reporting), to accompany the researcher when visiting international institutions and reporting (2 weeks), to provide technical advice (2 weeks equivalent) and to write and edit final report (4 weeks)
2. Equipment for each participating research institution:
    a) 4-wheel drive vehicle (including maintenance and running)
    b) Cutting measuring, meteorological and survey equipment, axes, fencing materials, camping equipment, books and documentation.
3. Workshop facilities and accomodation, travel and expenses
4. Visits of the consultant to each of the institutions
5. Visits to an international institution by five research workers and the consultant
6. Exchange of scientists between the five participating institutions
7. Funds for analysis, such as calorific value measurement, or lignin content, by other institutions
8. Funds to assist yearly reports
9. Expenses incurred in field work
10. Final reporting

Proposed schedule (in months)

0 - 1 1/2	Preparation of the workshop by the consultant
1 1/2 - 2	Workshop: Ordering equipment
3	Initiation of research by participating institutions
6 - 7	Visit to participating institutions by the consultant and report
15	First interim report by participating institutions
19	Visit to international institutions
27	Second interim report by participating institutions
29 - 30	Second visit to participating institutions by the consultant and report
39	Third interim report by participating institutions
40 - 42	Final report by the consultant

Duration 3 1/2 years.

RESEARCH COMPONENT C.3. BUDGET

Consultant for 3 1/2 months (over 3 1/2 years)		41,000
Travel		7,000
Subsistence allowance	60 x 150	9,000
Secretarial assistance		600
Workshop:		
Travel	1000 x 5	5,000
Subsistence allowance	60 x 7 x 5	2,100
Documentation	250 x 5	1,300
Sundries		1,000
Equipment		
a) vehicle	10000 x 5	50,000
maintenance 1st year	5000 x 5	25,000
maintenance and spare parts years 2 & 3	6000 x 5 x 2.5	75,000
b) scientific and technical	8000 x 5	40,000
c) camping	1500 x 5	7,500
d) fencing	4000 x 5	20,000
e) documentation	1000 x 5	5,000
Visit to an international institution and exchange of scientists -		
Travel	1000 x 5	5,000
Subsistence allowance	60 x 22 x 5	6,600
Funds for external analysis		10,000
Assistance for three annual reports by participating institutions	500 x 3 x 5	7,500
Assistance for field allowances during 3 years	40 x 60 x 3.5 x 5	42,000
Editing and printing final report		4,000
		364,600

RESEARCH COMPONENT C.3. ANNUAL BUDGETS

	1st Year	2nd Year	3rd Year	4th Year
Consultant	12,000	12,000	12,000	5,000
Travel, subsistence & secretarial	5,200	5,200	5,200	1,000
Workshop	9,400			
Equipment - vehicle purchase	50,000			
Vehicle maintenance	25,000	30,000	30,000	15,000
Other equipment	72,500			
Field allowances	12,000	12,000	12,000	6,000
Scientist exchange		11,600		
External analysis				10,000
Annual reports		2,500	2,500	2,500
Final report				4,000
	186,100	73,300	61,700	43,500

RESEARCH COMPONENT D

THE IMPACT OF AGROFORESTRY ON FOOD PRODUCTION

Background

Agroforestry emphasizes particularly the use of trees and other woody perennials in support of agriculture. In this project the subject is examined from two points of view, firstly the direct production of food by the trees themselves (leaves, flowers, fruits) and secondly the impact of trees on the production of food by other crops. The two components are entitled therefore:

D.1 Production of food by woody plants

D.2 Indirect impact of woody plants on food production.

For D.1, much information already exists, covering the non-wood benefits of trees, including their productivity in AF systems, particularly in West Africa. Some of the information is still being collected, or is unpublished, and much wider dissemination is needed.

For D.2, the methodologies developed at ICRAF for studies on the tree-crop interface are proposed. The number of tree species would be concentrated on trees likely or known to have potentially beneficial effects on food crop production. However, in situations where species such as Eucalyptus are used close to crop plants, evaluations of their effects could also be made. This might be particularly relevant in the context of windbreaks and shelterbelts, and there would therefore be strong linkages with Component C.1 of Project C.

RESEARCH COMPONENT D.1
PRODUCTION OF FOOD BY WOODY PLANTS

Objectives

To collect and disseminate information on woody plants producing food for rural populations. To assess the quantity of food from woody plants presently used by rural populations, and to improve design of agroforestry systems and the management of food producing woody plants in them.

Activities

1. It is proposed that nine groups of people be studied, and that the project would have the following activities:

   In a few selected ecological zones, survey and document the utilization of food produced by woody plants; the survey should be conducted within homogeneous ethnological groups, and stratified where possible by sex, age, etc. A calendar of utilization should be prepared.

   Suggested zones are, accorded to arid lands classification:

   B.1.a: Kababish of the Sudan, Maures of Mauritania
   B.1.b: Rendille and Samburu of Kenya
   C.1.a: Baggara of Southern Kordofan (Sudan), Dogon of Mali, Sarakoli of Mali
   C.2.b: S.W. of Madagascar
   D.1.a: Niokolo-Koba area in Senegal
   D.2.a: S.W. of Burkina Faso
   For each of these 9 groups, a supporting local institution would be found.

2. Investigate a selection of management practices aiming at facilitating the utilization of food-producing woody plants in agroforestry systems and improving productivity, and measuring their impact on food production. Such practices include:

   - pruning and shaping a broad-crowned fruit tree such as mango or tamarind to reduce the shade effect,
   - cutting roots on one side of a tree to be used in a hedge to reduce competition with adjacent crops
   - cutting tips of branches of a tree producing edible leaves like *Moringa oleifera* at different seasons and periodicity, to stimulate the production of young leaves
   - thinning buds on a woody plant producing edible flower buds such as *Boscia senegalensis* to study the effect on the edible biomass of buds.

3. With the results obtained prepare proposals to apply the acquired knowledge in various agroforestry systems.

Inputs required

1. Establishment by a consultant of a format for the inquiry (one week).
2. Secondment to the participating institutions, or recruitment, of two research assistants for each of the group identified, for three months, for field survey and report.
3. Analysis by the consultant (3 weeks) of the reports produced by the groups.
4. Workshop (1 week) organized by an international organization (ICRAF would be most appropriate) with the consultant, the team leader of each of the groups, and observers.
5. Production of a global report (4 weeks) on the surveys and on the workshop with recommendations for a programme of R/D on food producing woody plants for agroforestry systems.
6. Production by a specialized institution of research plans to test management practices for food producing woody plants. These plans should be implemented by any institution in dry Africa willing to do so: the production of a detailed report covering a three-year period of experimentation on a pre-designed format would follow.
7. Preparation of a report on the results of the experiments, with recommendations, by the institutions involved.

Proposed schedule (in months)

0 - 1	Establishment of format for the inquiry
	Nomination of 18 research assistants for 3 months each
2 - 3	Field survey by research assistants
2 - 3	Production of research plans to test management practices in collaboration with the research institutions
4	9 Reports by research assistant
5	Reports sent to the consultant
5 - 9	Initiation of test management practices by institutions
6	Analysis of reports by the consultant
7	Workshop
8	Global report on surveys with recommendations
40 - 44	Production of reports on test management practices
45 - 48	Global report on test management practices with recommendations

Duration 4 years.

RESEARCH COMPONENT D.1

BUDGET

Consultant: 9 weeks	16,000
Travel	3,000
Subsistence allowances 5 weeks	2,000
Support to the 9 teams of two persons for 3 months:	
subsistence allowance	65,000
transport	11,000
Workshop	
9 journeys	
specialized institution participation (1 man month equivalent)	7,500
Research planning by specialized institution	2,000
Preparation of detailed report on testing management practices (6 reports expected) 500 x 6	3,000
Final report on the results of experimentation on management practices	7,500
	117,000

ANNUAL BUDGETS

	1st Year	2nd Year	3rd Year	4th Year
Consultant	4,000	4,000	4,000	4,000
Subsistence & travel	1,250	1,250	1,250	1,250
Field teams - subsistence	16,250	16,250	16,250	16,250
- transport	2,750	2,750	2,750	2,750
Workshop	7,500			
Research Planning	2,000			
Reports on management				3,000
Final report				7,500
	33,750	24,250	24,250	34,750

RESEARCH COMPONENT D.2
INDIRECT IMPACT OF WOODY PLANTS ON FOOD PRODUCTION
(Studies on the tree-crop interface)

Objectives

To study the biological and environmental interactions between trees commonly used on farms trees, and on annual crops in different agroforestry systems, especially in shelterbelts, hedgerows live fences, boundary planting and intimate tree-crop mixtures.

Activities

Three institutions are proposed for the project which would have the following activities:

1. Preparation and publication of an annotated bibliography on the tree-crop interface.

   Establishment of a set of research plans common to participating institutions with the technical backstopping of a specialized international institution such as ICRAF.

2. Selection of species to be tested. The following are suggested:

   First priority: *Acacia albida*, *Butyrospermum parodoxum*, *Parkia biglobosa*
   Second priority: *Acacia tortilis tortilis*, *A. tortilis raddiana*, *Tamarindus indica*, *Parkinsonia aculeata*, *Leucaena leucocephala*, *Prosopis africana*, *A. senegal*
   Third priority: *Spondias* sp., *Detarium* sp., *Dialium* sp., *Balanites aegyptiaca*, *Piliostigma* sp.

It is suggested the experimentation for each species be conducted by three different institutions and countries. The following are suggested: -

- for *Acacia albida*: C.N.R.F. Senegal, Jebel Marra Rural Development Project (Sudan), I.N.R.A.Z.H. de Katibougou (Mali)
- for *Butyrospermum paradoxum*: Mali, Burkina Faso, Niger, Nigeria
- for *Parkia biglobosa*: Burkina Faso, Mali, Nigeria, Senegal
- for *Acacia tortilis tortilis*: Sudan, Mauritania, Djibouti, Kenya
- for *A. tortilis raddiana*: Sudan, Mauritania, Niger
- for *Tamarindus indica*: Mali, Kenya, Madagascar
- for *Parkinsonia aculeata*: Cape Verde, Niger, Madagascar
- for *Leucaena leucocephala*: Gambia, Burkina Faso, Kenya
- for *Prosopis africana*: Senegal, Niger, Kenya
- for other *Prosopis* species: Senegal, Sudan, Somalia
- for *Acacia senegal*: Senegal, Niger, Sudan

3. Initiation of research by participating institutions.
4. Recruitment of a consultant to assist in preparing the research plans (3 weeks), to visit the participating institutions (2 x 2 months) and to assist in preparing the final synthesis and recommendations (3 weeks).
5. Production of interim reports after 18 months, by the participating institutions.
6. Exchanges of scientists between the projects.
7. Production of final reports after 36 months, by the participating institutions.
8. Synthesis of these reports by backstopping institution with the consultant and publication of a final report with recommendations.

Proposed schedule (in months)

0 - 1	Selection of the backstopping institution
1 - 2	Selection of the consultant by the backstopping institution
3 - 4	Preparation and distribution of the research plans
5 - 8	Initiation of research by participating institutions
9 - 10	Consultant visits the participating institutions
23 - 26	Interim reports
28 & 29	Consultant visits the participating institutions
41 - 44	Final reports of the participating institutions
45 - 48	Global final report.

Duration 4 years.

RESEARCH COMPONENT D.2

BUDGET

Consultant:	3 weeks + (2x2) months + 3 weeks (over 4 years)	38,500
	Travel	6,000
	Subsistence allowances	6,000
Backstopping institution: research planning & preparing reports equivalent 2 m.m.		15,000
management (approx. 10% of the cost)		10,000
Exchange of scientists between 15 institutions for 1 month:	travel 1000 x 15	15,000
	Subsistence allowances 60 x 30 x 15	27,000
Clerical assistance for final report		800
		118,300

ANNUAL BUDGETS

	1st Year	2nd Year	3rd Year	4th Year
Consultant	9,625	9,625	9,625	9,625
Subsistence & Travel	3,000	3,000	3,000	3,000
Backstopping	6,000	6,000	6,000	7,000
Scientist exchange	21,000	21,000		
Final report				800
	39,625	39,625	18,625	20,425

RESEARCH ON AND DEVELOPMENT OF NATURAL REGENERATION TECHNIQUES FOR THE SILVO-PASTORAL MANAGEMENT OF EXISTING FOREST RESOURCES

E.G. Bonkoungou
Directeur de l'IRBET
BP 7047
Ouagadougou, Burkina Faso

and

R. Catinot
former Directeur-General
C.T.F.T.
Nogent-sur-Marne, France

TABLE OF CONTENTS

	Page
A. Long-term objectives	90
B. Immediate objectives	91
C. Special considerations	92
D. General information and justifications	92
1. Ecology	92
2. Development	93
3. Phenomena of environmental degradation	93
4. Justification of the intended action	94
E. Expected results	96
1. In the short term from the end of the project	96
2. In the medium term	96
3. In the long term	96
F. Action	97
1. Geographic localization	97
2. Design of a methodology to tackle management	97
3. Identification of the research to be carried out	101
3.1 Ecology (bioclimatology)	101
3.2 Inventory and photointerpretation techniques	102
3.3 Methodology to estimate the volume and the productivity of a stand	102
3.4 Stand regeneration methods	102
3.5 Management of stands and their productivity	103
3.6 Stand dynamics	103
3.7 Development of an agroforestry system based on natural regeneration	104
3.8 Development of a pasturing system based on natural regeneration	104
3.9 Bush fires	105
3.10 Special research studies	105
3.11 Appropriate research plots	105
4. Technical coordination, education and extension	105
4.1 Coordination programme	106
4.2 Education programme	106
4.3 Extension programme	107

TABLE OF CONTENTS CONTD.

Page

5. Dissemination of scientific and technical information 107

G. Funding 107

1. Sample list of the personnel to be employed in each Pilot Centre 107
2. Expenses of the donor(s) 108
   - 2.1 Personnel 108
   - 2.2 Materials and equipment 108
3. Expenses of the state(s) 110
   - 3.1 Personnel 110
   - 3.2 Buildings 110
4. Total expenses per 10 000-ha Centre 110
   - 4.1 Budget covering the contribution of the donor(s) 111
   - 4.2 Budget covering the contribution of the state(s) 112

Appendices 113

A. LONG-TERM OBJECTIVES

The states which lie in the Sahelian and North Sudanese zones, the objects of this study, fortunately still possess extensive mixed forest and grassland communities. Although a complete inventory of them has never been carried out, it is estimated that they cover about 50 million ha, to which can be added about 6 - 8 million ha of productive forest fallow (1). Their forest potential varies considerably from 0.5 - 1.0 m^3/ha in some Sahelian regions to 18 - 20 m^3/ha in the richest North Sudanese communities. The same is true for their herbaceous potential, which is proportionately more consistent in the Sahel than in North Sudan.

Although these potentials have been widely made use of by the people in Africa, they have never been managed in the economic and ecological senses with a view to non-destructive exploitation complemented by regeneration operations ensuring a sustained yield and their continued existence in time and space.

If little thought was therefore given to their future, the phenomena of desertification and the energy crisis have in the last fifteen years brought a reminder of the importance of these plant communities, which provide the only source of energy for the people of these regions and the only food source for their livestock, as well as acting as a buffer against desertification.

From that time their maintenance became a primary objective for the authorities of the states concerned, but in order to ensure this they first turned to artificial regeneration techniques resulting in forest plantations whose success was not compatible with a herbaceous cover and which moreover required high-yielding forest species to be used, thus excluding African species. Therefore a move was made towards plantations without a herbaceous layer carried out with exotic species (Eucalyptus, Azadirachta, etc.) whose

---

1. These estimates have been made from studies carried out by FAO/UNEP (Tropical forest resources assessment project) and from studies by the CILSS, which appear to show at least a 5% forest cover.

heavy cost ($800 - 1000/ha) precluded the planting of large areas, which would be the only way to solve the increasingly worrying problem of deforestation. All these problems showed the limits of such a strategy which, if generalized, would have led to an impasse if only because these plantations were not well received in rural areas as they only provided wood, whereas the people expected much more from forest communities (forage, condiments, medicines, etc.), which the exotic species planted were incapable of providing.

It was thus that under the influence of some of the technical staff the idea of turning to natural communities took root in the minds of the authorities, on condition that precedence be given to their abilities to regenerate naturally by coppice shoots, suckers or seedlings to compensate for their regression, and that they be managed in such a way as to produce a sustained yield not only of wood but also of forage and all the other traditional products expected by the rural population.

The long-term objective thus consists of ensuring as far as possible the maintenance of mixed natural communities (forest and grassland) so that they continue to ensure protection against desertification and satisfy as widely as possible the requirements for wood, forage and traditional products expressed by the people. If aridity persists, or accelerates (which is under debate at present), management of natural communities can only help to combat this tendency to the extent that it allows for conservation of the maximum forested area.

B. IMMEDIATE OBJECTIVES

The technical tool allowing the permanent objective thus described to be achieved is called Management: this is an operation consisting firstly of precisely defining the objectives set for the forest community which has been taken charge of (protection, production, type of products), then of devising a plan in time and space of the operations to be carried out to achieve these objectives, and lastly of defining and calculating the funds required and the corresponding economics.

As such operations have never been carried out in the Sahelian and Sudano-Sahelian zones of Africa (except in a very incomplete manner in Senegal), models of silvo-pastoral management based on natural regeneration techniques must rapidly be established, which will entail the setting-up of a complete research system to solve the numerous problems of the natural regeneration of mixed forest and grassland communities.

This research could be established in separate plots as part of the permanent work of research organizations working in this zone, but this would risk running into serious difficulties in the ecological choice of the plots and their geographical distribution, and in the coordination of operations. Also, as it must be recognized that the Management techniques themselves must be discovered or adapted, it would seem more sensible to create a pilot Management centre for each ecological zone involved and to set up the research plots within each of these pilot centres. Apart from the considerable advantage gained by the concentration of operations and funds, there would also be the certainty that the research would be carried out full scale and in the development centre itself. This perfectly fits the definition of the research and development operations which form the objective. It is quite clear that the education/extension branch, which should be given adequate importance, can only benefit fully from such a concentration which would make it possible to tackle all the problems at the same time.

The present Project thus aims in the immediate future to devise, set up and run a pilot operation for experimental Management for each ecological zone during the five years granted to it, and to make it the testing ground for the research and education/extension programmes which seem to be indispensable for the development of a silvo-pastoral management model adapted to the Sahelian and North Sudanese zones.

C. SPECIAL CONSIDERATIONS

First of all one must be aware that such operations, where so many new methods have to be found, adaptations carried out and hypotheses tested, should continue much longer than the five years of the Project. On the other hand, no-one is unaware that in forestry experimentation it is extremely rare to be able to draw reliable results in five years. Therefore the Project will basically form a stage, certainly indispensable for the foundations it will have laid, but which should be continued by the national or regional organizations which will ultimately take it over.

As many psychological errors have already been made with regard to the local populations as far as the approach to tropical forest problems is concerned, a Project such as this should take special notice of the human factor if its effect is not to decrease rapidly over the years. In this regard a special effort should be made in the training of specialized personnel intended later to develop similar operations in the various states, and in the area of explaining the techniques and results to the people, starting with the neighbouring populations: without their total approval no definite progress can be achieved.

Finally, because of the communication problems peculiar to these countries, particular care should be taken in the choice of the site for each pilot Management centre in order to reduce the travelling costs related to education and coordination. In spite of everything, the value of ecological sampling of the site should take precedence over all other considerations as far as reasonably possible.

D. GENERAL INFORMATION AND JUSTIFICATIONS

1. Ecology

Taking account of the climatology and the vegetation types it seems sensible to distinguish three different ecological facies in the zone involved in the Project:

- Sudano-Sahelian facies (sometimes called 'North Sudanese') with an annual rainfall between 600 mm and 800 mm
  $600 \text{ mm} < P < 800 \text{ mm}$
  The forest communities are of the 'wooded and shrubby savannas' type (Anogeissus, Butyrospermum paradoxum, Acacia albida, etc.) and comprise 5 to 18/20 m^3/ha.
- Sahelian facies (sometimes called 'Sahelo-Sudanese') with an annual rainfall between 400 mm and 600 mm
  $400 \text{ mm} < P < 600 \text{ mm}$
  The forest comunities are of the 'shrubby savannas and steppes' type (Balanites, Acacia seyal, Boscia, etc.) and comprise 3 to 10/12 m^3/ha.
- Sahelo-Saharan facies (sometimes called 'Sahelian') with an annual rainfall between 200 mm and 400 mm
  $200 \text{ mm} < P < 400 \text{ mm}$

The forest communities are of the 'steppe' type (Acacia raddiana, Acacia senegal, seyal, etc.) and comprise 0 to 5/6 m^3/ha.

2. Development

Very different according to facies:

- 600 mm < P < 800 mm: intensive agricultural development (millet, sorghum, peanut) and part stationary, part transhumance animal rearing. The development of the forest communities to be considered should give priority to wood production rather than forage production.
- 400 mm < P < 600 mm: agricultural development concentrated mainly in the cool zones with animal rearing dominant (mainly transhumance). Wood or forage production should take precedence depending on the ecological conditions.
- 200 mm < P < 400 mm: agriculture concentrated around pools, with animal rearing predominant (transhumance or nomadic). In these conditions forage production should become predominant in a silvo-pastoral system. It should be noted that the persistent drought has disturbed traditional practices and made grazing more and more transhumance and destructive, especially on fallow land. It thus greatly disturbs the traditional agrosilvo-pastoral balance and overall has led to a southward movement of the grazing area in search of new pastures. The majority of workshop members thought it wise to combine the two classic ecological facies, 600-400 mm and 400-200 mm, into a single management zone, 600-200 mm.

3. Phenomena of Environmental Degradation

It is acknowledged now that the persistent drought of the last fifteen years has only accentuated the phenomena of degradation in an often dramatic fashion, which insidiously advanced into the natural vegetation associations of the arid zones and which sooner or later would become apparent to even the least watchful eye.

One cannot with impunity 'cheat' with ecology and submit regions with limited ecological potential (Sahel and North Sudan) to unreasonable pressures of human occupation. Where rainfall is less than 400 mm/year, only light livestock pressures (1 cow to several hectares or tens of hectares) are permissible; between 400 and 600 mm/year, cultivation cannot be carried out everywhere; and between 600 and 800 mm/year soil fertility will not be maintained unless fallow periods of more than 3 to 5 years are respected or unless agricultural crops are permanently under the broken cover of forest trees (Acacia albida and, to a lesser extent, Butyrospermum paradoxum/Parkia), or unless agriculture and grazing are always combined in all cases.

Through not wishing to see the danger or having forgotten it, Contemporary Man has taken considerable risks with the arid tropical zones since the end of World War II. Trusting in the economic theory of 'continual expansion', he often in an apparently oblivious manner mortgaged the future of these regions by sacrificing ecology to economics: under the pretext of carrying out agricultural or pastoral 'development' only yielding short-term benefits, he sterilized entire areas in the medium or long term by exhausting fragile soils by repeated cultivation or overgrazing through blind development, rarely connected to prior pedological or ecological studies. Cultivation has frequently been carried out on any site as long as the indigenous population were thus ensured of a temporary economic and financial profit which they then considered as the beginning of permanent prosperity. In most cases they closed their eyes to two limiting factors: the considerable population growth (2.5 - 2.8%/year), and the poor ecological potential offered by the regions they wanted to develop. This manifested itself by a turn to clearings, to 'pastures new', which proceeded at an alarming rate through the arrival of more and more young cultivators and the development of more and more fragile soils as they became exhausted more rapidly than other soils. At last this was manifested in an uncontrolled expansion of animal rearing, which was 'extensive and contemplative' with increasing requirements. Faced with natural communities already depleted by the persistent drought as if by a steam-roller, animal rearing is moving southwards and disturbing more and more a natural balance which is already precarious.

The combination of these phenomena leads to a continually more marked degradation of the environment which can be characterized:

- on the qualitative level: by a regular reduction in the length of fallow periods, which in some regions have already practically disappeared (Mossi Plateaux, Bassin arachidier of Senegal,...) leading to both a reduction in soil fertility and a reduction in fuelwood resources, which will eventually cause problems for which it is difficult to see a solution;
- on the quantitative level: by a gradual disappearance of the forested areas, the rate of which is difficult to assess but which makes one fear that in the next fifty years 2/5 of the forest areas of the Sudano-Sahelian zone will have disappeared (cf. Appendix No. 1). Because the cleared areas are in general the most accessible and often the best, one can only be extremely worried about the consequences of such a phenomenon and acknowledge that everything must be done to attempt to check it.

4. Justification for the Intended Action

The Project planned, silvo-pastoral management based on natural regeneration, is completely justified on two counts:

- The certainty that the forest communities of these regions vigorously regenerate naturally either by coppicing (production of stem shoots), production of suckers or by seedlings (germination of seed fallen on the ground) as long as they are protected against fire and browsing. Although there is little experience of forestry management in arid zones, some studies have been carried out for 40 years on the natural regeneration of forest communities of Sudano-Sahelian savannas (Cameroon, Nigeria, Niger, Burkina-Faso, Mali). They have shown that coppicing followed by protection of these savannas leads to a considerable increase in the number of plants (suckers, seedlings) and an increase in productivity. The increase in the natural potentials thus obtained is such that the productivity level often approaches that of forest plantations established in the same area. From our present knowledge we can calculate as follows for the zones concerned:

	Yield, m^3/ha/year			
Rainfall mm/year	Well-maintained plantations	Badly-maintained plantations	Natural regeneration	Comments
$600 < P < 800$	2 - 4	1 - 2	0.50 - 1.50	1. below 600 mm/year plantations are no longer reliable
$400 < P < 600$	1 - 2	-	0.10 - 0.75	
$200 < P < 400$	-	-	-	2. below 400 mm/year even natural regeneration is unreliable

This table shows that with an annual rainfall below 600 mm the results produced by the plantations are poor and irregular such that in this ecological facies natural regeneration appears to be the only reliable system; but below 400 mm this also becomes unreliable such that in this facies it is wise to prohibit systematic exploitation and to give the forest communities essentially a protection role (in the Appendices you will find technical notes relevant to characteristic research plots).

On the other hand, below 600 mm considerable herbaceous potentials still exist, and below 400 mm pastoral management should take over and become the prime objective, using both the herbaceous and woody forage resources.

Taking account of these potentials, it is clear that a systematic attempt at silvo-pastoral management based on natural regeneration is necessary in order to complement or take over from forest plantations and rationalize animal rearing on the economic level, and to preserve the role of ecological protection of these natural communities. In effect, if no attempt is made to make use of them by managing them, they will inexorably disappear under the combined onslaught of bush fires and clearing in such a way that this will be irreversible: by giving them an aim, a purpose, Management alone can save them.

However, it is obvious that this Management must be all-encompassing and include all available potentials (forestry, pastoral and 'traditional' - medicines, honey, condiments, etc.) if it is to be accepted by the people and attain a reasonable level of profitability. The more marginal the environment or the poorer the resources, the more the approach to develop should be all-inclusive and try to develop all the resources: this is a well-known rule in economics.

E. Expected Results

1. In the Short Term from the End of the Project

- The specification of a general methodology for approaching the possible management operations in the Sahelian and North Sudanese zones (preliminary elements to be collected, conditions to be fulfilled);
- One or several management models adapted to each of the three facies of the zone, capable of guaranteeing the annual production of a certain number of m^3 of wood but also of forage units (U.F.);
- A preliminary estimate of expected profits;
- A large number of results of studies or research allowing the main technical loans to be raised, against which the management projects are now coming up;
- The training of a large number of national specialists in management and research, as well as competent extension workers;
- A preliminary education exercise in the rural areas for the benefit of the management, starting with the extension work carried out during the project;
- The establishment of a preliminary network for the exchange of information and specialists between the states in the zone.

2. In the Medium Term

- The setting up and realization of a growing number of management projects for the benefit of the states but also of the communities;
- The improvement of research results, making the management operations progressively more reliable and more economic;
- The gradual development of public opinion with regard to the natural forest, tending to regard it as community property which should be protected and respected.

3. In the Long Term

If the project sets off the desired development, the Management should be expressed in operations on three levels:

- on the local level: the management of forests belonging to communities (villages);
- on the communal level: within the framework of agrosilvo-pastoral management:
    - allocate to the commune and manage for it the area of forested land necessary to satisfy economic requirements (wood, forage) and ecological ones (shade, relaxation);
    - carry out special protection work where necessary (forested windbreaks in agricultural areas or anti-erosive plantings along isohyets).
- on the regional and/or national level: establish the borders of the permanent national forest and its extent with the aim of preserving a sensibly distributed forested area with regard to the human population distribution and the communication network, as well as the protection/production balance necessary for the maintenance of the conditions guaranteeing the future of a Nation.

F. Action

1. Geographic Localization

The possibility of creating a pilot Management Project by ecological facies results from the preceding justifications, with the understanding that the research classed as indispensable would be carried out in each of the pilot Projects.

For reasons of current circumstances and wisdom, we indicated earlier that only two eclogical zones should be retained, 800 mm < P < 600 mm and 600 mm < P <200 mm. However, taking into account the phenomena of "continentality" and "maritime influence" as well as the needs expressed by every state, we suggest four pilot Centres, two to be responsible for the 800 mm < P < 600 mm zone and two for 600 mm < P < 200 mm.

The selection of the countries containing one of these facies and the precise siting of the pilot Project within the country constitute the first stage of action of the Project. We consider that each pilot Centre chosen should cover about 10 000 ha, i.e. about 40 000 ha for the whole Project.

2. Design of a Methodology to Tackle Management

Although once again no silvo-pastoral management scheme is operating in the arid zones of Africa which could be used as a reference, from now on a certain methodology can be proposed, inspired by projects currently being studied, which will allow the Project to 'take the plunge' and to be modified later in relation to the actual circumstances encountered, to eventually present a refined and operational methodology.

It goes without saying that the gradual application of this first form of management will allow research topics to be promoted to be identified, based on the actual state of the site, and to be immediately carried out as part of the Project itself while this is confined solely to natural regeneration.

We thus believe that in a second stage those in charge of the Project preferably should strive to develop a provisional management model which should be strongly influenced by the three classical phases of forest management:

Phase 1: analysis and interpretation of data previously collected by inventories, enquiries and studies on the forestry and pastoral aspects as well as the socio-economic and human aspects.

Phase 2: definition of the objectives to be set for management (production, protection, leisure, overall).

Phase 3: definition and precise planning in time and space of the operations required to reach these objectives.

In order to adapt this traditional strategy to the zone and objectives concerned in the Project, account must be taken first of one essential fact: the forest communities ('savannas' and 'steppes') always possess a herbaceous cover and from time immemorial have been considered by the people as suppliers of wood and pasture. Thus in order to institute Management of these communities, plans should be made for:

- an exploitation plot providing:
  - * m^3 of wood corresponding to requirements
  - * F.U. of forage corresponding to requirements
- a regeneration plot ensuring a sustained and balanced production of these two products;
- a method of calculating the maximum annual production of these two products corresponding to the ecological potentials of the sites concerned, the technical term for which is the annual capacity, in
  - m^3/ha/year
  - F.U./ha/year

This measure will allow the permissible levels of forest exploitation and livestock pressure to be legally limited.

From these considerations, and to give the implementors of the Project some sort of technical outline, we present below a schematic model to guide them. It may appear rather vague, but because of the lack of known references it is often difficult to escape from generalities. In any case, its object is to serve solely as an aid to a full-scale operation which will allow the research capable of filling the gaps in our knowledge to be identified and carried out.

PILOT PROJECT
for experimental silvo-pastoral Management
Example of an instruction sheet

Phase 1: Collection, analysis and interpretation of data

1.1 Basic data (climate, geomorphology, relief, hydrography, water tables)
1.2 Pedological (or agropedological) study → Ecological map (Soil/Vegetation)
1.3 Qualitative vegetation study
(photointerpretation)
- forests
- grasslands → Ecological map (Soil/Vegetation)

1.4 Quantitative vegetation study
(inventory by strips or plots)
- forests → frequency curves (Number/); → m^3 of available wood; → F.U. available for wildlife and livestock
- grasslands → F.U. available for wildlife and livestock

1.5 Quantitative wildlife study
(inventory)

1.6 Socio-economic study
(enquiries, interviews)
- number of villages concerned
- corresponding population
- agriculture
  - crops (ha/person)
  - fallow (ha/person)
  - cultivation systems
- pasturing
  - number of breeders
  - head of cattle
  - head of sheep
  - head of goats
  - grazing range
  - transhumance
- other products

- honey, wax
- medicines
- lianas, bamboos, straw
- food

1.7 Predetermination of management series

- exploitation series →
  - forests
  - forage
- regeneration series → according to the inventories
  - forests
  - forage
- protection series → according to the ecological map
- utilization series
  - agricultural →
  - pastoral →
  - traditional → according to the socio-economic study

Phase 2: Definition of the objectives set for Management

2.1 Choice between all-inclusive management (many functions) connecting production and protection and a sectional management (production or protection)

2.2 Choice of the priority to be given to the forestry sector or the pastoral sector according to the ecological potentials and the economic and human requirements

2.3 Allocation to the state or the communities of the products of management (forest, pastoral or traditional)

2.4 Subjection of the management of these production systems either to the traditional rules or to the rule of the specialized authorities ('submission to the forestry regime')

2.5 Determination of the amount of the managed area to be allocated to subsidiary research (forestry and pastoral)

2.6 Choice between management for sustained yield or for optimum yield, taking account of the ecological, economic and human factors.

Phase 3: Definition and planning of corresponding operations

3.1 Deciding on the regeneration techniques

- forests: coppice (in such ecological systems coppice-with-standards or high forest are not possible because of the structure of the stands and the impossibility of relying on systematic natural sowing) with or without planting or treatments encouraging suckers, with or without protection; date of fellings and rotations;
- pastures: rainy season grazing and/or mowing, dry season grazing, forage trees, with or without forage crops;
- soils: type and length of fallow periods, forested or grassed fallow, agroforestry, protection and restoration of soils.

3.2 Deciding on exploitation techniques

- forests: deciding on techniques of coppice felling, date of fellings for an optimum economic yield and taking account of the availability of labour, retention of a few trees per hectare to provide poles;

- pastures: mowing and conservation techniques (ensilage), optimal dates for wet and dry season grazing, deciding on grazing ranges (free, controlled, length of stay) according to utilization phases, use of local forest species (pruning, defoliation);
- soils: crop rotations, agroforestry.

3.3 Deciding on the type of management and its parameters

- type of management: obviously in monocyclic coppice the exploitation rotation corresponds to the regeneration rotation;
- rotation length: variable according to the ecological conditions, in this zone it could vary between 12 - 15 years and 18 - 20 years;
- management by capacity or volume: in spite of the heterogeneity of the natural communities, management by capacity is the only type that can be envisaged because of the complexity of estimating standing volumes. From the results of the inventory an attempt will be made to compensate for the heterogeneity of the natural communities by dividing the exploitation areas into different sizes.

3.4 Definition of the arrangement of plots

- division of the area into management plots: except where there is an extremely dense topographic network (tracks, rivers), which is extremely rare in these regions, it is recommended at first to use the inventory plots as the management plots
- grouping into series:
  - exploitation and regeneration series: when under coppice management they are obviously combined, which simplifies things a great deal;
  - protection series: covering the areas where dangerous erosion occurs, either naturally or through human actions. As part of the management plan, they could be exploited after a certain number of rotations. They may only affect the passage of fire which is forbidden here, while the rest of the area suffers early fires;
  - utilization series: covering the zones where the manager allows the traditional utilization rights to be exercised whether they are regulated or not; the exercise of these rights may be permanent or temporary.

3.5 Elaboration of the management Plan

- type and quota of exploitation: on the forestry level all the exploitation series (and possibly some of the utilization series) should be exploited once during the rotation. The annual quota of fellings would then be equal to the quotient of the standing volume of these series at the time of the inventory divided by the number of years of the rotation; as the estimation of this last figure is carried out so that at the end of the rotation there is a standing volume at least equal to the initial potential, the production should not decrease from one rotation to the next ('sustained' production). On the pastoral level the cycle of exploitation will usually be annual because of the growth cycle of the vegetation cover;
- type and amount of regeneration: both in forestry and pasturing, as this coincides with exploitation as it occurs spontaneously by coppicing, its qualitative and quantitative cycle will follow that of the exploitation. Nevertheless, the regeneration could be improved by treatments triggering the production of suckers (soil cultivation) or by planting (seedling plots), but which could normally be carried out at the time of exploitation, thus not disturbing the management. However, it would be as well to prohibit fire and grazing (or at least have controlled grazing) during the five years following the exploitation/regeneration operations;

- establishment of the management Plan: this is now possible as, with the data above, all the elements are gathered together to set the number of hectares of forest and pasture to be exploited and regenerated, as well as the allocation of products between the state and the communities, and finally the 'annual capacity of the forest' which is equal to the quotient of the overall production estimated during the rotation divided by the number of years of the rotation (this is the mean for this period): this is expressed in m^3 of wood/ha/year and in F.U./ha/year and will thus allow the maximum number of head of livestock allowed in the managed area to be calculated, as well as the m^3 of wood felled.

3.6 Establishment of the regulation of exploitation: this is the regulation which sets for each year of the coming rotation the plots of each series where the exploitation, regeneration or protection operations planned in the management Plan will be carried out, as well as their types and amounts. This is a very difficult document to produce, especially for silvo-pastoral management, as it can only result from compromises between the demands of forestry and grazing, whether it is a case of the time treatments are carried out, their nature, the technical impossibility of allowing grazing in the years following forest regeneration, etc. Numerous revisions of the management will be necessary before a satisfactory document can be produced.

3.7 Approach to the economic and financial yield of the Management: Management is in general conceived to produce a positive result because its aim is to rationalize development operations which have been disorganized thus far. But like any long-term operation it first costs money. In the circumstances, the pilot Projects for silvo-pastoral management will in their initial phase present too many inaccuracies and unknowns for a reliable calculations of financial and economic yield to be carried out immediately; nevertheless it is indispensable that the bases of this be laid straight away so that those in charge know 'where they are going' as the Project progresses and can identify as quickly as possible the sections to be corrected.

3. Identification of the Research to be Carried Out

By returning one by one to the operations proposed in the attached 'Example of an instruction sheet', and taking account of the level of our present knowledge, it is easy to identify the lines of research to be undertaken within the geographical limits of the present Project. Starting with the terrain problems encountered it will certainly allow the programme to be completed, which can be set out as follows.

3.1 Ecologicy (bioclimatology)

As each pilot Project should have a small meteorological station it would be opportune to test the most representative parameters of forestry and pasturing in arid zones. In this regard the saturation deficit should be carefully calculated parallel to the PET in order to check whether, as there is every reason to believe, the saturation deficit shows itself to be the most representative parameter of the aridity of a site, which is becoming more and more a limiting factor for the ecology of arid zones.

It would seem highly advantageous to promote a regional programme whereby Meteorological Services were made responsible for saturation deficit, and to encourage agencies such as Agrymeth to chart regional isolines of saturation deficit; as well as a similar agency in East Africa. An agency such as ICRAFT could well act as a 'driving force' in this area, by demonstrating the full extent of its practical use in East Africa.

3.2 Inventory and photointerpretation techniques

- Devising methods to study the woody layer and the herbaceous cover at the same time, as they are at present identified and inventoried separately; extension of the inventory to bamboos or plants with a traditional importance;
- adaptation of sampling rates to the ecological conditions and to the objectives set;
- taking advantage of the latest techniques (remote sensing, automatic cartography,...) in order to reduce the cost of the operation.

The Project should offer very favourable conditions for such research because of the variety of ecological parameters (three different facies). It would be realistic firstly to carry out the inventory of each pilot Project by classical methods, then in the name of research to carry out the programmes above, for which the value could easily be verified.

3.3 Methodology to estimate the volume and the productivity of a stand

The very poor average form of the trees of the savanna and their frequent appearance as coppice has always been a severe handicap to their measurement. Thus it is important to consider the following programmes:

- establishment of volume tables adapted to each ecological zone and to the production objectives (fuelwood, timber), as the present tables are not precise enough to estimate the volume of standing timber. The methods of measuring standing trees should also be reviewed;
- development of techniques permitting the volume of roundwood to be measured precisely at the research level (immersion tanks, etc.), as the traditional method, consisting of stacking smallwood into steres and applying 'known' stacking coefficients, leads to research results which are often inconsistent from one site to the next;
- carrying out of systematic research on conversion coefficients between units of measurement (m^3, steres, weights) according to the dryness of the wood. This operation, which should be carried out equally in all three ecological facies, would be of great interest not only on the research level but also on that of trade in fuelwood which is at the moment very worried by the lack of reliable measurement units (faggots, small piles, non-metric 'steres', etc.).

In a word, the unification of measurement methods starting from reliable data is of great urgency as many disparities between research results that occur at present come from using divergent and often erroneous norms, and the trade is completely in the dark.

3.4 Stand regeneration methods

It is known that under present conditions the natural stands regenerate mainly by coppice shoots, a little by suckers and very rarely by natural sowing. However, there is good reason to believe that if they could be protected from fire and browsing the last forms of regeneration would be much more prolific. The proof of this has already been provided by a number of well-protected research plots (Burkina-Faso, Niger) where a clear increase in the number of young trees established between the existing coppice trees has been established, which could only have come from suckers or seedlings (see Appendices); furthermore, planting trials carried out by direct sowing on a soil which had only been scratched have been totally successful in the Niger plot. There is every reason to believe that the same is true for the herbaceous layer. Therefore it would be very important to develop the following programme both for forestry and pasturing:

- capacity of the main species to regenerate from shoots and suckers (possibly using the quadrat method, field trials or container trials);
- phenology of these species and the germinative capacity of the seed;
- optimum date and height of coppicing (mowing for herbs);
- role of fire in regeneration (especially for herbs);
- possible associations between certain forest species and herbs;
- increase in the production of suckers by cultivation between the trees in a coppice stand (grader, rooter,...);
- improvement of direct sowing by superficial cultivation of the soil in certain seasons (scarifier);
- supplementary plantings, if the natural forest potential for management is insufficient.

3.5 Management of stands and their productivity

The treatment universally recommended being coppice, the problem lies in determinng the optimum rotation length and the yields obtained at different dates (1). Plots of known area should be established, for which first of all the inventory should be made of the natural stand, which would be coppiced and measured; then at a set date every year for twenty years a new inventory and measurement of standing trees should be carried out. Thus the optimum rotation length to be adopted for this type of ecology and stand could be defined, which would be that from which one would obtain a standing volume at least equal to the initial volume. Here one must recognize the importance already noted of the establishment of accurate volume tables. The productivity of the stand treated thus in m^3/ha/year can be found by a simple calculation.

3.6 Stand dynamics

The development of stands treated in this manner can be evaluated at two levels:

- quantitatively: this is the development of standing volume as a function of treatment age (productivity) which results form the research described above and makes it possible to draw a curve of productivity as a function of age, which is always of great technical and economic interest;
- qualitatively: this is what botanists call 'stand dynamics' and which reflects the development of its botanical composition; in effect, because of this sort of

---

(1) This treatment would not necessarily apply to groves of Acacia nilotica (nilotica or Gonakie), which could receive treatments suited to their current vegetative state.

treatment, a certain number of species invade. This research is of great technical and scientific interest (where is the stand heading?), as well as economic interest according to whether the invading species are important or not: in the latter case one can try to correct the phenomenon by planting high quality species.

3.7 Development of an agroforestry system based on natural regeneration

This is based on the idea that as long as one accepts making a certain number of provisions when agricultural cultivation is started, a forest potential can be preserved in agricultural areas sufficient to satisfy some of the requirements of the people. To this end, we propose the following research programmes:

- conservative techniques of forest regeneration using non-destructive cultivation methods: either by pruning, of an intensity to be defined, to preserve a certain number of seed trees in the agricultural fields, or by the retention in these same areas of a certain number of small diameter (D <20 cm) coppiced trees at the start of cultivation, of which a certain number of shoots will be retained. Numerous trials will be required to determine the optimum number of trees compatible with a sufficient yield of the agricultural crop, as well as the most suitable species (probably leguminous). Such practices would presumably be compatible with two years of crops followed by fallow, as during this period the trees should remain alive;
- techniques facilitating the return to forest fallow at the end of the crop cycle: by deep scarification (heavy cross-kill) immediately after the last crop harvest in order to trigger the production of suckers from still living tree roots (cropping cycle ≤3 years);
- agroforestry rotation techniques: handing over a plot of natural forest to the rural population which fells it and plants agricultural crops under the supervision of the forest service (cutting to ground level, no burning, retention of a few pruned seed trees). This would be a type of controlled taungya (without planting) which has given convincing results at Shaba (Zaire), which would be followed by fallow protected from fire, then returned to cropping, etc. A true agroforestry rotation would then be achieved.

3.8 Development of a pasturing system based on natural regeneration

This is a priority programme as the success of silvo-pastoral management ultimately depends on it. It has already given rise to many trials with few successes. However, as so much depends upon it, it is absolutely essential to return to it, taking note of the research already carried out or in progress (Mare d'Oursi in Burkina-Faso, Ferlo in Senegal,...). The programmes are well-known:

- identification of forage trees
- appropriate pruning or leaf-thinning techniques (intensity, season, frequency)
- browsing or pruning
- grazing on herbs in the dry or wet season in relation to forest regeneration
- mowing (techniques, equipment, preservation of forage)
- role of fire in the regeneration of herbs (useful or harmful)
- permissible livestock pressure
- planting of forage trees along grazing routes

As these problems appear to have different solutions according to the ecological conditions, this Project could effectively undertake them as it has three different ecological facies at its disposal.

3.9 Bush fires

Although this has been tackled many a time with varying degrees of success, this topic deserves to be taken up as part of this Project as it has different solutions according to the ecological conditions and could therefore be treated in its silvo-pastoral entirety, starting with ecological comparisons which could be of interest. It should include:

- the effect of late fires on forest and pasture (destruction of seedlings or suckers);
- the effect of early fires;
- the effect of fire according to the age of the regeneration (should fire only be allowed 2, 3, 4 or 5 years after coppice rotation ?);
- the resistance of the main species according to age (from what age do they become resistant ?);
- the development of firebreak preparation techniques according to the ecological zones (clearing of brush, incineration, incineration of central bands, etc.).

3.10 Special research studies

Many will become necessary as the Project progresses. However, the following can already be suggested:

- on the forestry level, the study of growth rings in wood, often making it possible to tell the age of the trees (cf. CTFT/Niger - Ader-Doutchi);
- research on a more complete utilization of the products of natural stands:
    - systematic technological study of all the forest species;
    - study of the resins, latex, etc.;
    - study of the properties of certain flowers and leaves (Senegal exports 100 t/year of Combretum leaves for tea);
    - study of the products destined for craftsmen (bamboos).

3.11 Appropriate research plots

Much of the research could be established in very simple plots, if possible with statistical replication. In an appendix (Appendix IV) a classical version of this type of plot is presented, which should be surrounded by a large number of protective devices (firebreaks, guarding against man and his livestock). Experience has consistently shown the appeal that such plots have for the indigenous populations, who come and illegally remove an unfortunately large amount of the products which they traditionally look for in natural forest stands.

4. Technical Coordination, Education and Extension

As much as on its technical success, the final impact of such a Project depends on the success it has in training specialists and in persuading the rural population of its importance. It will also depend on the uniformity of action between the programmes and their execution in the pilot centres planned for the zone. Therefore a programme of coordination, education and extension must be planned for the five years of the Project.

4.1 Coordination programme

Plans must be made for at least five meetings, one a year, during which the future programmes will be established together and what has been achieved will be reviewed. At these rotating meetings (successively in the three centres) the Principal Technical Advisor, the Chief forester and the Chief pastoral manager (cf. further on, the planned organization) of each centre will participate. Each of these meetings will obviously give occasion for a detailed tour of the host Centre and discussions on the terrain.

4.2 Education programme

4.2.1 Training of planning staff: We start from the following two considerations:

- the best training in contact with the realities of the site will be given within the framework of the Project as long as each trainee receives it in each of the three pilot Centres in turn, in order to have an overall idea of the problems;
- the forest and pastoral researchers and managers to be trained will follow the same courses, because at the present stage of our knowledge silvo-pastoral management and research are still closely interrelated, and at the development stage it would be excellent for everyone to made aware of all the problems of the others.

Under these conditions we propose the following organization:

- the courses will be planned as workshops lasting three weeks including work on the site;
- they will be directed in each pilot Centre by the Principal Technical Advisor, for whom this will be one of the main roles and who will be chosen accordingly (from the 3rd year they will be directed by a section head);
- in each of the three pilot Centres four workshops a year will be organized concentrating on the following specializations:
    - inventory and photointerpretation techniques;
    - natural regeneration techniques; development of stands; ecology;
    - exploitation and development techniques (agroforestry, crop rotations);
    - silvo-pastoral management techniques;
- in each pilot Centre these Workshops will take up 12 weeks/year (about three months);
- each trainee could thus follow all the workshops of the three pilot Centres in one year and thus profit from a complete training which would last 36 weeks in all (about nine months) as long as the workshops are carefully coordinated between the three Centres.

We estimate that each workshop could accept about ten trainees at a time, which would make it possible to train 50 specialists in five years if all of them followed all the workshops at all the Centres, and many more if some of them were only interested in certain courses. This system appears to us to be sufficiently flexible to cope with all possible eventualities and to require the minimum outlay.

4.2.2 Training of technical personnel:
This can be assured at each pilot Centre by providing them with a large number of young native technicians to be trained and assigned by the Principal Technical Advisor to a programme of work, the timetable for which would be arranged in advance. It would be

best for them to take a turn at all the activities of the Centre because of their broadly-based vocation. It would be very useful for future extension workers also to follow this training.

For economic reasons it is not intended to accept technicians from other states unless they agree to pay all the costs.

4.3 Extension programme

It would be advisable to start the first extension operations with the rural populations from the pilot Project stage. In this regard, a regular system of visits to the area should be planned, organized for the benefit of the neighbouring rural communities at the time that the main operations (inventories, regeneration fellings, controlled grazing, etc.) are being carried out, and giving them the opportunity to express their requirements, hopes and fears.

5. Dissemination of Scientific and Technical Information

We believe that this absolutely essential operation should be planned and carried out at the level of the whole of the IUFRO Projects on research and development because of the interdependence of the topics chosen and the overall organization that they require (communication networks, etc.).

G. FUNDING

In order to clarify the distribution of costs between the Donor and the states involved, we first present a sample list of the personnel that it appears advisable to take on at each pilot Centre. As the silvo-pastoral inventory of each Centre will be the first operation to be carried out, which will demand additional personnel (compass readers, chainmen, counters, etc.), this personnel will appear on the sample list as 'extraordinary personnel' to be employed for the 4 months this operation will take.

1. Sample List of the Personnel to be Employed in Each Pilot Centre

1 Foreign principal technical advisor (for the first three years)
1 Chief forester
1 Chief pastoral manager
1 - 2 Foresters (depending on the ecological conditions)
1 - 2 Pastoral managers (depending on the ecological conditions)
2 - 4 Forest rangers (depending on the ecological conditions)
2 - 4 Pastoral rangers (depending on the ecological conditions)
7 Office specialists (2 Statisticians, 1 Draughtsman/Cartographer, 2 Secretaries, 1 Accountant, 1 Nurse)
7 Site specialists (5 Drivers, 1 Prospector, 1 Topographer)
6 'Extraordinary personnel' specialists (Inventory)
15 Permanent workers
5 Temporary workers
5 Consultants (Photointerpretation, Dendrometry, Administration, Pedology, Sociology)

2. Expenses of the Donor(s) (exchange rate used: US $1 = 400 CFA)

2.1 Personnel

1 Principal technical advisor (3 years)		36 h/month
1 Photointerpretation consultant/Centre		1 h/month
1 Dendrometry consultant/Center		1 h/month
1 Administration consultant/Centre		1 h/month
14 Specialists/Centre		
14 x 12 x 5 years x $150 =	$ 124 400	840 h/month
15 Permanent workers		
15 x 12 x 5 years x $88 =	$ 79 200	900 h/month
5 Temporary workers		
5 x 12 x 5 years x $90 =	$ 27 000	300 h/month
18 'Extraordinary' specialists		
18 x 4.5 months x $150 =	$ 12 150	81 h/month
Moving and travel expenses, coordination, training	$ 65 000	

2.2 Materials and equipment

Site equipment:

1 Bitterlich relascope	$ 700
1 Blumeleiss dendrometer	$ 375
1 scintoclinometer	$ 50
4 tape measures (diameter)	$ 100
3 forest compasses	$ 890
3 metal tape measures	$ 300
2 walkie talkies (5 W/25 km): inventory and fire prevention	$ 2 750
1 set of meteorological equipment	$ 5 000
Subtotal	$10 165

Calculating equipment:

1 calculating machine (scientific functions) $800 = $ 800

Office and photointerpretation equipment:

2 manual typewriters	$ 1 650	
1 cartographic plotter	$ 1 650	
Subtotal		$ 3 300
1 microcomputer		$ 3 000
Subtotal		$ 7 100

Transport:

This entry may appear rather large, but it should take account of the continual travel of management and workers over distances of 10 000 ha and of trainees.

2 4 x 4 Diesel trucks	$29 000	
1 4 x 4 504 station wagon	$12 000	
1 Toyota 14 hp diesel pick-up truck		$12 000
2 Toyota 9 hp diesel pick-up trucks (twin cab)		$11 000
4 3 hp cars (2 to be replaced once in the 3rd year)		$20 000
6 motorcycles	$ 4 000	
Subtotal	$88 000	

Construction materials (assistance to States to invest in buildings and other installations (roads, etc.)	$55 000

Non-durable equipment:

site: hatchets, machetes	$ 5 000
office and drawing	$ 5 000
Subtotal	$10 000

Accommodation supplies for various coordination and training meetings (bedding, cooking equipment, etc.)	$20 000

Vehicle maintenance:

Vehicles:

2 trucks		
2 x 150 CFA x 10 000 km/year x 5 years = 15 000 000 CFA =		$ 37 500
1 station wagon		
1 x 70 CFA x 15 000 km/year x 5 years = 5 250 000 CFA =		$ 13 125
3 Toyota pick-up trucks		
3 x 75 CFA x 15 000 km/year x 5 years = 16 875 000 CFA =		$ 42 187
4 cars		
4 x 60 CFA x 20 000 km/year x 2.5 years = 12 000 000 CFA =		$ 30 000
6 motorcycles		
6 x 10 CFA x 10 000 km/year x 5 years = 3 000 000 CFA =		$ 7 500
Subtotal		$139 812
	x 3 =	$419 436

Office and miscellaneous:

sundry supplies (office, drawing, medical)	$ 15 000
Documentation	$ 7 500
Computer analysis of inventory results	$ 5 000
Subtotal	$ 27 500
Communication of results $2 500	$ 2 500

3. Expenses of the state(s)

3.1 Personnel

2 Managers for 5 years	120 h/month
3 Technical staff for 5 years	160 h/month
5 - 6 Field staff for 5 years	320 h/month
1 Consultant pedologist	1 h/month
1 Consultant sociologist	2 h/month

3.2 Buildings and installations: As the Donor has already undertaken responsibility for a $55 000 envelope for investment in buildings and installations, the state will provide the project with the sum of 25 million CFA, if required.

4. Total expenses per 10 000-ha Centre

Donor(s)	$ 1 000 000 U.S.
State(s)	125 000 000 CFA

4.1 BUDGET COVERING THE CONTRIBUTION OF THE DONOR(S) (ONE 10 000-HA CENTRE)
($ U.S.)

	COSTS											
	Total		1986		1987		1988		1989		1990	
Items	h/m	$	h/m	$	h/m	$	h/m	$	h/m	$	h/m	$
10 Personnel												
11 Technical personnel												
01 Principal technical advisor	36	306 000	12	102 000	12	102 000	12	102 000	-	-	-	-
02 Consultants	3	25 500	3	25 500	-	-	-	-	-	-	-	-
13 Support personnel												
01 Specialists	840	124 400	168	24 880	168	24 880	168	24 880	168	24 880	168	24 880
02 Permanent workers	900	79 200	180	15 840	180	15 840	180	15 840	180	15 840	180	15 840
03 Temporary workers	300	27 000	60	5 400	60	5 400	60	5 400	60	5 400	60	5 400
04 Extraordinary	81	12 150	81	12 150	-	-	-	-	-	-	-	-
specialists	-	65 000	-	13 000	-	13 000	-	13 000	-	13 000	-	13 000
Section total	2160	639 250	504	198 770	420	161 120	420	161 120	408	59 120	408	59 120
40 Equipment												
41 Durable equipment												
01 Site		10 165		10 165		-		-		-		-
02 Calculation and office		7 100		6 000		1 100		-		-		-
03 Transport		88 000		80 000		8 000						
04 Building		55 000		55 000		-		-		-		-
42 Non-durable equipment (office, drafting, site)		10 000		2 000		2 000		2 000		2 000		2 000
43 Accommodation and training supplies		20 000		20 000		-		-		-		-
Section total		190 265		173 165		11 100		2 000		2 000		2 000
50 Maintenance												
01 Vehicles		139 812		14 000		28 000		30 000		32 000		35 812
02 Office, computing		27 500		8 500		5 000		5 000		5 000		4 000
03 Communication		2 500		1 000		-		500		-		1 000
Section total		169 812		23 500		33 000		35 500		37 000		40 812
Overall total		999 327		395 435		205 220		198 620		98 120		101 932

Grand total = 1 000 000 $ U.S.

4.2 BUDGET COVERING THE CONTRIBUTION OF THE STATE(S)
(CFA)

	COSTS											
	Total		1986		1987		1988		1989		1990	
Items	h/m	$	h/m	$	h/m	$	h/m	$	h/m	$	h/m	$
10 Personnel (including travel)												
11 Technical personnel												
01 Managers	120	36 000 000	24	7 200 000	24	7 200 000	24	7 200 000	24	7 200 000	24	7 200 000
Technical staff	160	28 000 000	32	5 600 000	32	5 600 000	32	5 600 000	32	5 600 000	32	5 600 000
Field staff	320	35 200 000	64	7 040 000	64	7 040 000	64	7 040 000	64	7 040 000	64	7 040 000
02 Consultants												
Pedologist	1	300 000	1	300 000	-	-	-	-	-	-	-	-
Sociologist	2	600 000	1	300 000	1	300 000	-	-	-	-	-	-
Section total	603	100 100 000	122	20 440 000	121	20 140 000	120	19 840 000	120	19 840 000	120	19 840 000
40 Equipment												
41 Durable equipment Buildings and installations	-	25 000 000		25 000 000		-		-		-		-
Section total		25 000 000		25 000 000		-		-		-		-
Overall total	603	125 100 000	122	45 440 000	121	20 140 000	120	19 840 000	120	19 840 000	120	19 840 000

Grand total cost = $125 000 000 CFA

APPENDIX I

Basic data on the consumption/forest resources balance: Prospects for 50 years (1980-2030) for Mali, Burkina-Faso, Niger, Senegal and Gambia combined (CILSS)

	Year				
Parameters	1981	1982	2000	2025	2030
Populations					
Rural population	20 000 000	20 400 000	29 150 000	47 800 000	52 800 000
Urban population	5 000 000	5 150 000	8 750 000	18 400 000	21 300 000
Total pupulation	25 000 000	25 550 000	37 900 000	66 200 000	74 100 000
Consumption					
Rural consumption (m^3)	15 000 000	15 300 000	21 862 000	35 850 000	39 600 000
Urban consumption (m^3)	3 750 000	3 862 000	6 562 000	13 800 000	15 975 000
Total consumption (m^3)	18 750 000	19 162 000	28 424 000	49 650 000	55 575 000
Forest areas					
Areas of clearing carried out since 1981 (ha)	-	250 000	5 178 750	17 375 000	20 500 000
Forest area (ha) (forest + 1/3 fallow)	50 000 000	49 750 000	44 281 250	32 625 000	29 500 000
Forest resources					
Natural increment 0.300 m^3/ha/year (m^3)	15 000 000	14 925 000	13 285 000	9 788 000	8 850 000
Yield of clearings 4 m^3/ha cleared (m^3)	-	1 000 000	1 440 000	2 360 000	2 604 000
Reforestation (m^3)	(25 000 ha)	(27 000 ha)	(175 000 ha)	(425 000 ha)	(500 000 ha)
2 m^3/ha/year	50 000	54 000	350 000	850 000	1 000 000
Total resources (m^3)	15 050 000	15 979 000	15 075 000	12 998 000	12 454 000
Balance					
Consumption/resources balance		-3 183 000	-13 349 000	-36 652 000	-43 121 000

From the study 'En Afrique francophone, l'avenir forestier tropical se jouera dans le cadre du monde rural'(R. CATINOT, Bois et Forêts des Tropiques, no. 203).

APPENDIX II

Technical Sheet on the Trial at Dounga (Niger)

1. Ecology

- Classified Guesselbodi forest, 30 km from Niamey
- Ferruginous soils, fairly good, little leaching
- Rainfall: 537 mm/year, over 9 years
- Located at the foot of a plateau at low altitude; the site may benefit from some accumulation of moisture

2. Establishment

In May 1974, on 2 625 ha of partially developed land

3. Objectives

To study the development of a savanna type of stand, as a function of:

- cutting height
    - treatment A: cutting at ground level
    - treatment B: cutting 50 cm from the soil
- cultivation ± sowing with seed
    - treatment C: scratching the soil
    - treatment D: scratching + sowing
    - treatment E: fish bones + sowing
    - treatment F: fish bones without sowing
- cutting date
    - treatments G to O between May 1974 and February 1975

4. Evaluation of results

Because means were lacking, only results from treatments A, B, and D could be evaluated. The following conclusions emerged:

- In all cases a sometimes spectacular increase in the number of stems occurred; treatment D seemed to be most effective and treatment A the most economical (see Appendix 3).
- In this plot, the natural productivity, generally estimated to be 0.5-1 st/ha/year increased to 3.25-3.75 st/ha/year (see Tables).

MONTHLY AND ANNUAL RAINFALL (mm), 1974-1982, NIAMEY AIRPORT SITE

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total annual
1974	0	0	0.3	0	6.6	40.7	167.2	206.3	56.3	22.5	0	0	499.9
1975	0	0	0	3.7	67.2	82.9	194.6	262.0	79.1	0	0	0	689.5
1976	0	0	0	0	77.0	71.4	114.5	215.2	82.2	29.1	0	0	589.4
1977	0	0	0.9	0	41.5	51.6	221.5	211.9	28.9	0	0	0	556.3
1978	0	0	30.2	54.0	65.2	99.0	96.6	195.3	102.1	23.5	0	0	665.9
1979	0	0	1.8	0.6	65.1	59.1	209.4	128.8	69.9	3.8	5.5	0	544.0
1980	0	0	0	Trs	28.8	83.6	106.3	120.5	83.9	5.3	0	0	428.4
1981	0	0	0	0	6.3	62.1	71.5	276.9	47.7	53.6	0	0	518.1
1982	0	0	0.2	15.6	33.2	35.0	73.9	135.3	43.3	4.9	0	0	341.2

Cumul : 4832.9 mm

QUANTITATIVE RESULTS

Species	Treatment A Productivity				Treatment B Productivity				Treatment D Productivity			
	Weight kg	kg/ha/yr	%	st/ha/yr	Weight kg	kg/ha/yr	%	st/ha/yr	Weight kg	kg/ha/yr	%	st/ha/yr
Guiera senegalensis	1 047.5	465	82	3.1	604.1	268.5	76	1.79	544.1	241.8	43	1.61
Combretum micranthum	58.6	26	5	0.13	66.3	29.5	8	1.15	110.5	49.1	9	0.25
Combretum glutinosum	72.2	32	13	0.16	84.0	37.3	11	0.19	369	164	29	0.82
Balanites aegyptiaca	21.4	9.5		0.05	6.7	3		0.01	29.4	13.1		0.06
Grewia	64.4	28.6	11	0.3	18.9	8.4		0.09	68.5	30.4	5	0.32
Combretum nigricans	11.5	5.1		0.02	7.8	3.5		0.02	41.6	18.5		0.09
Boscia angustifolia					6.3	2.8		0.01	4.0	1.8		0.01
Maerua angolensis									3.0	1.33		0.01
Feretia apodanthera	2.1	0.9		0.00					6.2	2.75		0.03
Dichrostachys glomerata	2.3	1.0		0.00					2.3	1.02		0.00
Ac. erythocalyx	1.7	0.75		0.00					0.2	0.1		0.00
Ziziphus mauritiana	2.0	0.9		0.00								
A. senegal									66	29.3		0.15
Bauhinia rufescens									3.7	1.6		0.01
Piliostigma reticulata									0.2	0.1		0.00
Maerua crassifolia									4.0	1.8		0.01
Stereospermum									0.7	0.3		0.00
TOTAL		569.75		3.76		353		3.26		557		3.37

APPENDIX III

Trial at Dounga, Niger: Development of Stem Numbers According to the Type of Treatment

Treatment: A = cutting at ground level + protection
B = cutting at 50-cm height + protection
D = treatment B + scratching of soil + sowing (broadcast)

Species counted	Trees present before cutting in 1974			Trees found in 1983			% Mortality due to cutting (74-83/74)			Trees started between 1974 and 1983			Trees started between 1974 and 1983 (per hectare basis)			% Regeneration (83 total/74 total)		
	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D
Guiera senegalensis	94	137	93	88	127	89	6	7	4	222	272	329	888	1088	1316	336	298	454
Combretum nigricans	3	3	9	1	1	6	66	66	33	4	0	8	16	0	32	166	33	156
Combretum micranthum	3	4	9	3	2	7	0	50	22	12	13	9	48	52	36	500	375	177
Combretum glutinosum	6	13	29	6	11	26	0	15	10	2	3	4	8	12	16	133	108	103
Balanites aegyptica	29	14	22	8	2	5	72	86	77	12	2	12	48	8	48	70	29	23

Analysis of results

APPENDIX IV

INSTRUCTIONS FOR THE EXECUTION OF THE COPPICING TRIAL

(Extract from the Report of the Committee for Forestry Research of Burkina-Faso, Ouagadougou, 29 - 30/11/82)

I. ESTABLISHMENT

- selection of a type of vegetation suitable for the production of fuelwood under a coppice regime. The type of soil on which the trial is to be established should be the most representative of the soils of the forest concerned;
- selection of an easily accessible site or planning for access roads;
- as the experiment is planned for twenty (20) years with a regime of complete protection against fire, the firebreak network should be planned to give the best protection possible.

A perimeter firebreak with double rides 10 - 12 m wide surrounding a strip of natural vegetation is therefore recommended. The rides should be weeded regularly soon after the rainy season, while in the strip of natural vegetation the grass should be cut and burned early. The blocks are separated by 10 - 12 m wide rides which also act as firebreaks.

Arrangement of plots (see diagram)

The plot consists of four replicated blocks. Each block is divided into four plots, which each contain an experimental subplot of 0.25 ha which will be used for observations and measurements.

The blocks are marked A to D.

In each block the order of coppicing of the plots at 5, 10, 15 and 20 years is decided in the first year. The plots are then numbered 1 to 4 according to this order.

Each plot should be permanently marked by boundary posts and signs carrying the block and coppice order number.

II. CONDUCT OF THE TRIAL

In year 0: the plots are inventoried (woody and herbaceous vegetation) and measured, in particular the 0.25 ha subplots. This is followed by cutting to ground level.

Inventory sheets are prepared for this purpose. For the volume measurement, there is a general table for natural forest species (see Appendix). The individual volume of each tree with a girth greater than or equal to 22 cm is given in the table. The volume of trees with a girth less than 21 cm is obtained after stacking into steres and using the stacking coefficient 0.5.

It would be a good idea to individually measure the volume of a few trees in order to adjust the proposed table.

After coppicing the stumps are classified by species and by diameter class (1 - 5; 6 - 10; 11 - 15; 16 - 20 etc.).

The natural regeneration present at the time of cutting is also inventoried.

In year 5: the coppiced plots are inventoried and measured. The volume measurement can be made on standing trees (if the height and diameter of the coppice shoots are sufficient) or by stacking into steres.

The following details are noted:

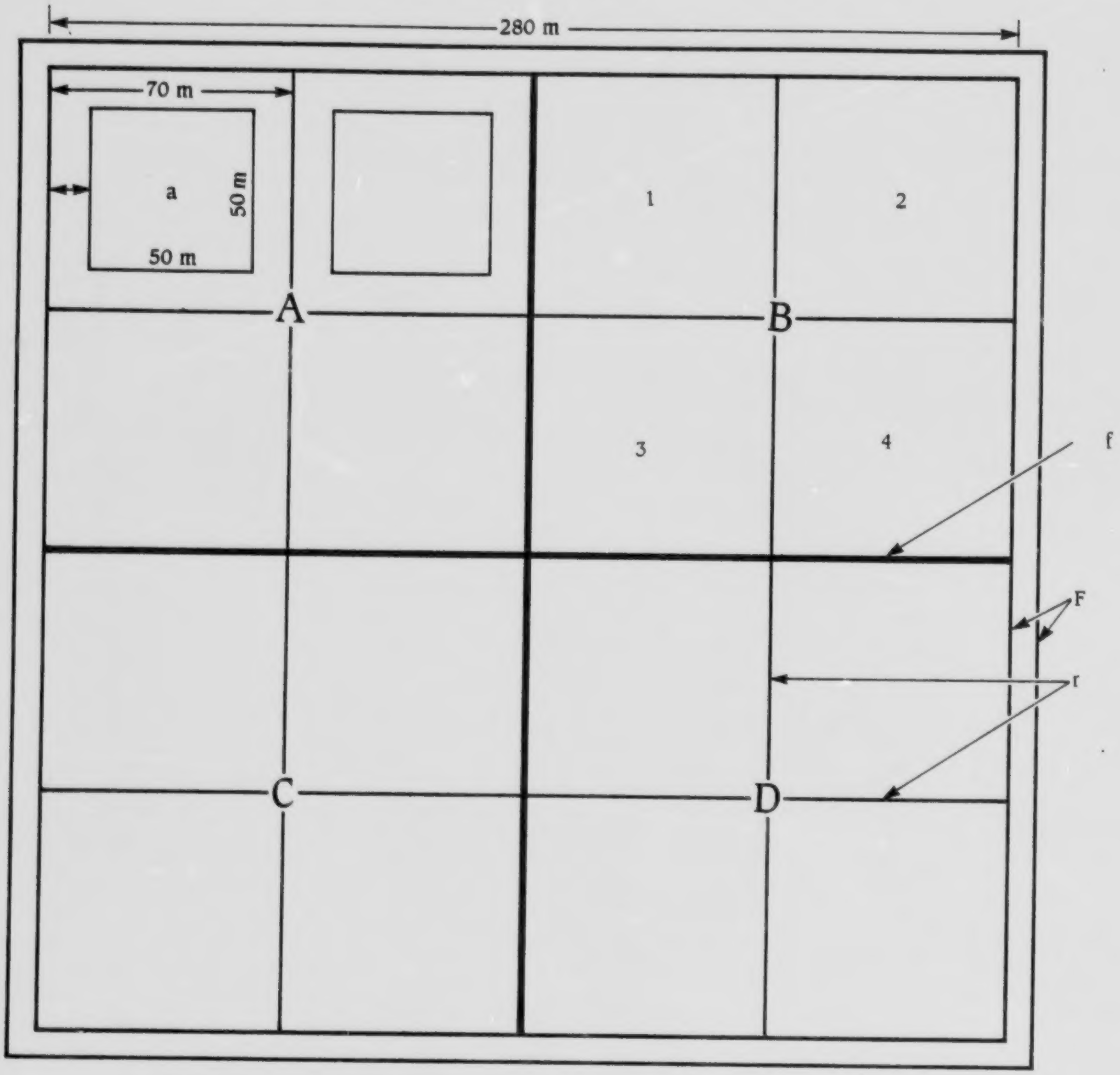
- the total percentage of coppice shoots (coppicing);
- the percentage of coppice shoots by diameter class;
- the percentage of coppice shoots by species and diameter class;
- the number and vigour of suckers by diameter class and species;
- the vigour of the coppice shoots (height and diameter growth);
- the natural regeneration (amount and vigour);
- the herbaceous cover (abundance, height and floristic composition).

All this information is written on one sheet for each plot.

In year 10/15/20: the same observations and measurements are made for the plots coppiced in these years.

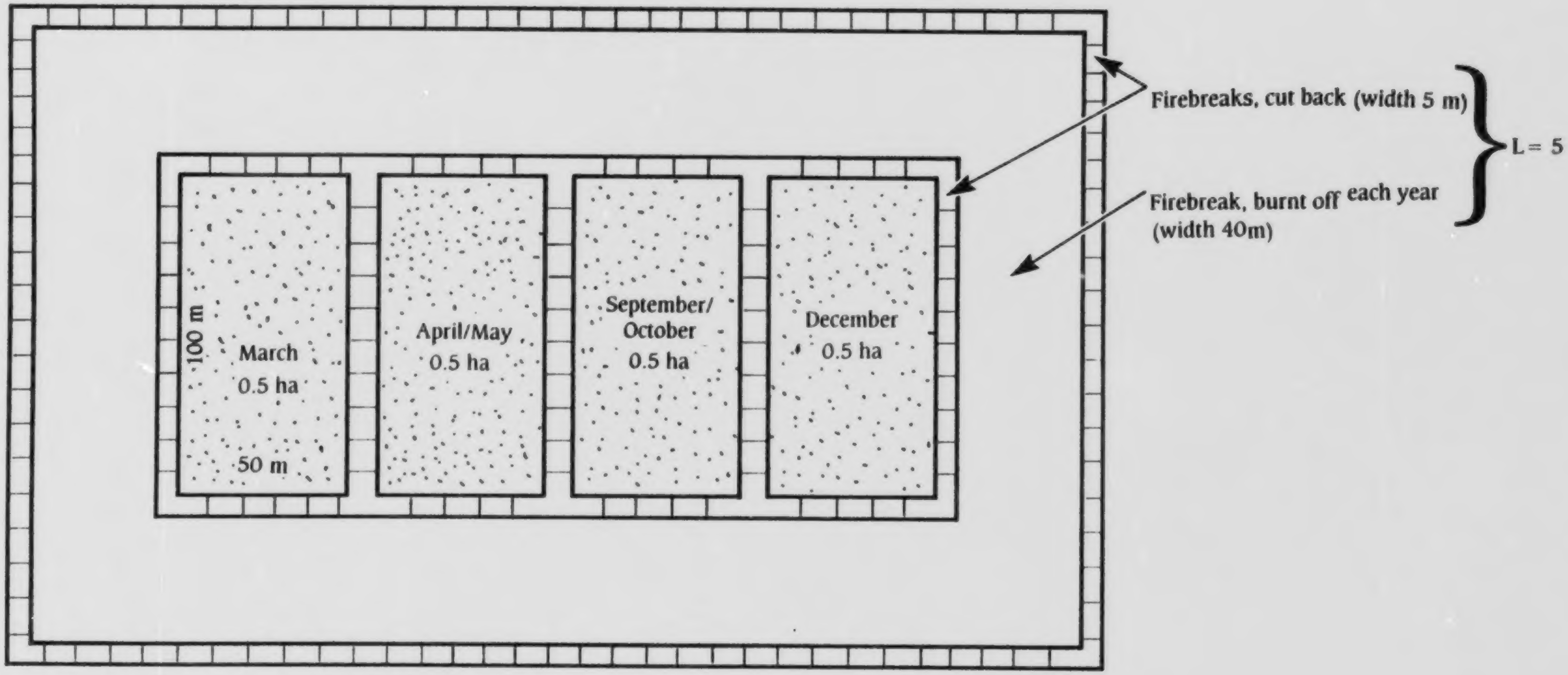
In year 20, the last year of the study, the curve for the development of the coppice can be drawn, using the rotation as the x-axis and the corresponding standing volumes on a per-hectare basis as the y-axis.

Plot for Coppice Trial (No. 1)


280 m
70 m
a
50 m
50 m
1
2
A
B
3
4
f
F
r
C
D

A, B, C, & D	replicated blocks
1, 2, 3 & 4 . .	elementary plots
a	0.25 ha subplots
p	protection strip 10 – 20 m wide
F	50 m wide double perimeter firebreak with a central strip of natural vegetation
f	10 – 12 m wide partition firebreak
r	2 – 3 m wide dividing ride

Management of Savanna by Coppicing
Determination of the Effect of Date of Cutting


Firebreaks, cut back (width 5 m)
Firebreak, burnt off each year (width 40m)
L = 5
March
0.5 ha
100 m
50 m
April/May
0.5 ha
September/
October
0.5 ha
December
0.5 ha

Research and Development of Natural Regeneration Techniques for Silvo-Pastoral Management of Existing Forest Resources
Site 2 — Zones of Project

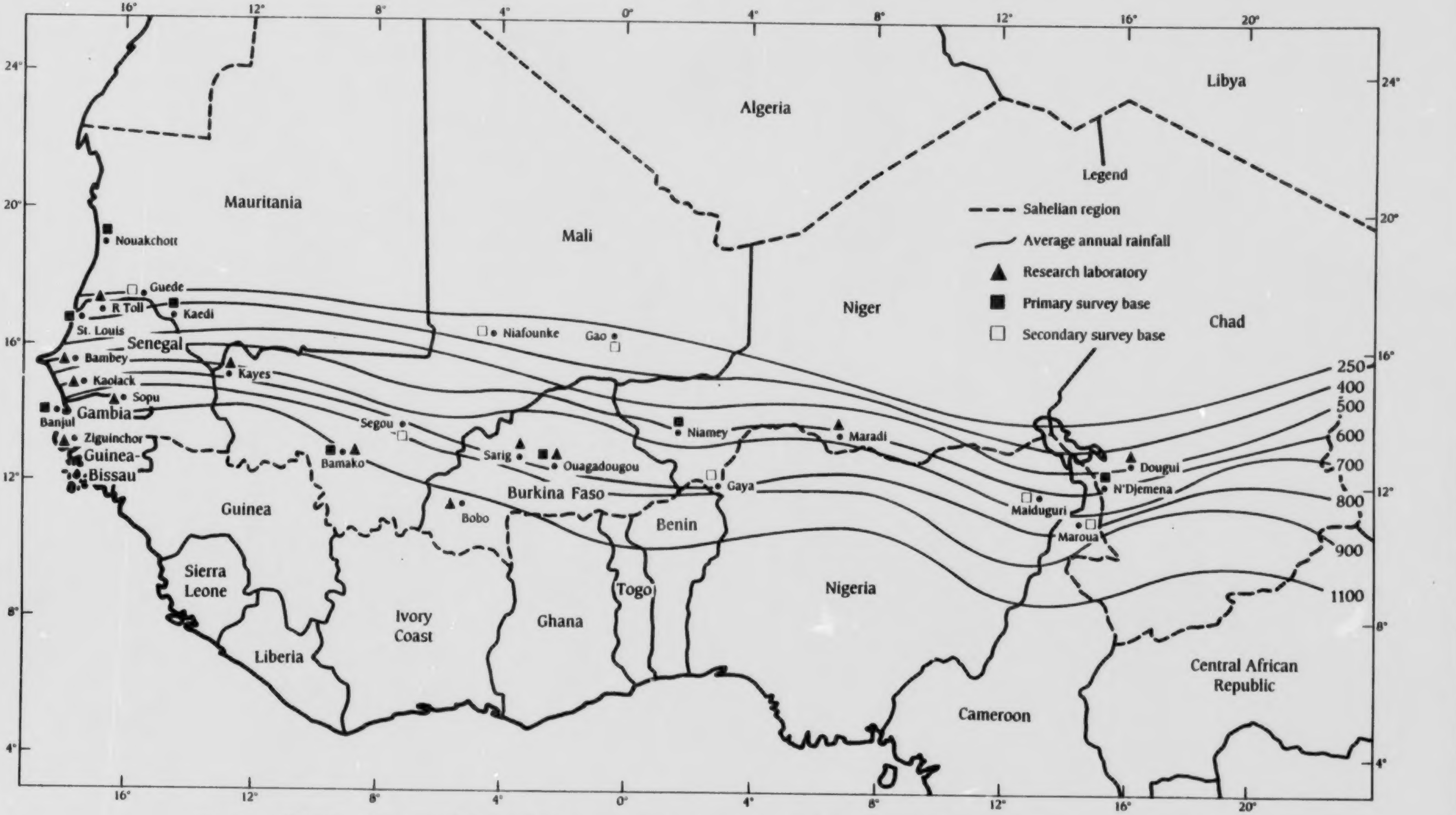
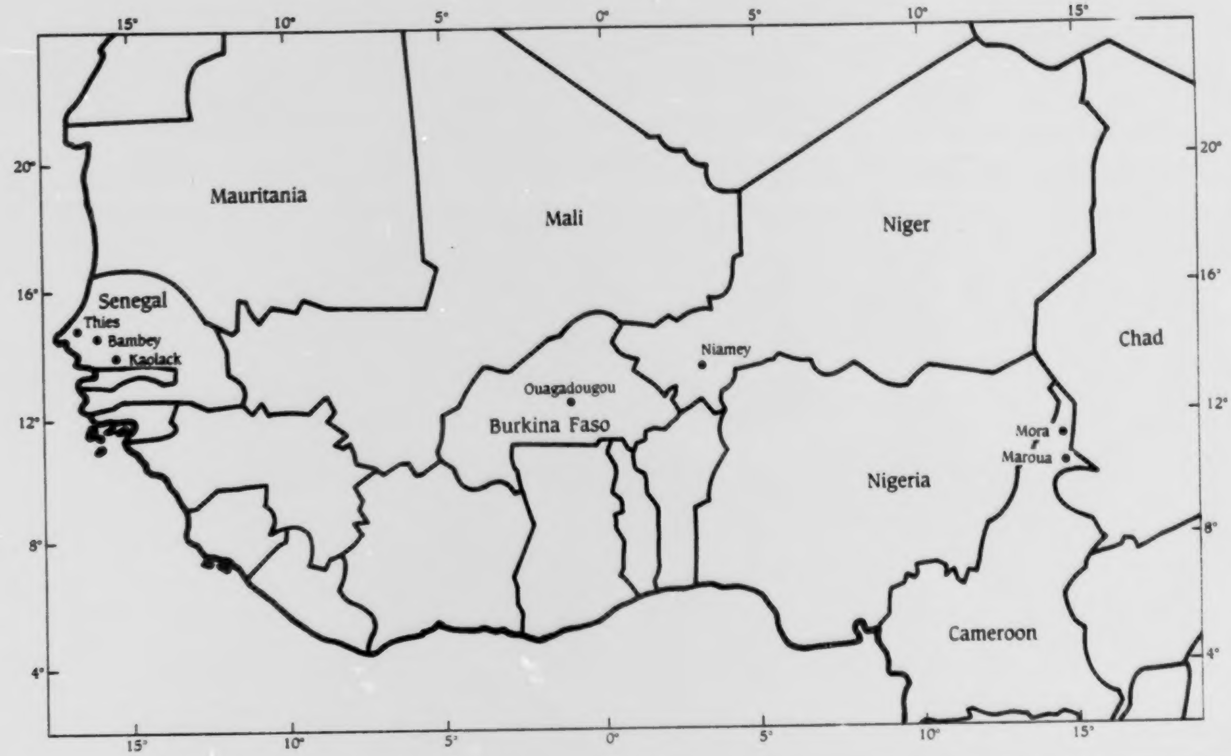

Legend
Sahelian region
Average annual rainfall
Research laboratory
Primary survey base
Secondary survey base
Libya
Algeria
Mauritania
Mali
Niger
Chad
Senegal
Gambia
Guinea-Bissau
Guinea
Sierra Leone
Liberia
Ivory Coast
Ghana
Togo
Benin
Burkina Faso
Nigeria
Cameroon
Central African Republic
Nouakchott
Guede
R Toll
Kaedi
St. Louis
Bambey
Kaolack
Sopu
Banjul
Ziguinchor
Kayes
Bamako
Segou
Niafounke
Gao
Sarig
Ouagadougou
Bobo
Niamey
Gaya
Maradi
Maiduguri
Maroua
Dougui
N'Djemena
250
400
500
600
700
800
900
1100
24°
20°
16°
12°
8°
4°
0°

Fig. 1 — CILSS Extent of the Sahelian countries; annual rainfall; establishment of integrated control activities of the project; research laboratories; primary and secondary survey bases.

Principal Climatic Parameters of the Trial Sites



Weather Station				Temperature			Humidity			Sunshine	Evaporation	Rainfall					
	Latitude	Altitude	Distance to nearest coast	Max. (Tx) for warmest month	Min. (Tn) for coolest month	Annual mean (Tx + Tn)/2	Mean for driest month	Mean for wettest month	Annual mean	Annual total	Annual total	Annual total	Number of days of rain	No. of months with less than 1 mm	less than 10 mm	less than 30 mm	more than 100 mm
Ouagadougou	12° 22'N	196	780 km	Period 1930 – 1967 39.6/Apr.	16.0/Jan.	28.4	Period 1951 – 1958 24% Feb.	78% Aug.	49%	Period 50-57 2541.4	Period 50-67 2690.4	Period 1930 – 1967 864.7	72	2	5	6	4
				Period 1968 – 1983 38.8/Apr.	16.2/Jan.	28.3					Period 68-83 2536.8	Period 1968 – 792.7	64.6	2	5	5	4
Maroua	10° 35'N	402	910 km	Period 1941 – 1957 40.6/Apr.	18.6/Jan.	28.5	Period 1945 – 1957 19% Feb.	79% Aug.	47%	Period 55-57 2840.7	Period 50-57 3733.2	Period 1946 – 1967 815.9	62.9	4	5	7	4
												Period 1968 – 1983 781.3	62.4	4	5	7	4
Mora	11° 03'N	438	940 km									Period 1934 – 1967 778.5	-	5	5	7	3
												Period 1968 – 1983 618.4	-	5	6	7	3
Niamey	13° 30'N	216	820 km	Period 1944 – 1958 41.3/Apr.	15.5/Jan.	28.9	Period 1949 – 1958 18% Mar	77% Aug.	42%	Period 50-57 2829.9	Period 50-57 3466.9	Period 1930 – 1967 590.6	51.5	3	6	7	3
												Period 1968 – 1983 555.2	47.9	4	6	7	2
Bambey	14° 42'N	20	65 km	Period 1951 – 1967 37.1/May	13.9/Jan.	26.7	Period 1950 – 1967 33.6% Jan.	76% Sept.	52.2%	Period 61-67 2940.0	Period 65-67 2450.8	Period 1928 – 1967 671.7	41.2	5	7	7	3
				Period 1968 – 1982 38.0/May	15.6/Jan.	27.4	Period 1968 – 1982 41.1% Feb.	79.9% Sept.	57.3%	Period 68-82 3060.0	Period 68-82 2340.7	Period 1968 – 1982 478.1	39.0	6	7	9	2
Thies	14° 48'N	71	25 km	Period 1940 – 1957 33.2/Nov.	15.3/Jan.	25.8	Period 1951 – 1956 50% Jan.	84% Sept.	67%	Period 53-57 3115.6	Period 50-57 1542.7	Period 1930 – 1966 681.0	48.3	3	7	8	3
												Period 1968 – 1984 450.7	35.3	4	7	9	2
Kaolack	14° 08'N	6	80 km	Period 1931 – 1957 39.2/Apr.	15.7/Jan.	27.9	Period 36-40 51-56 39% Jan.	81% Aug.	58%	Period 50-57 3498.2	Period 50-57 2452.2	Period 1930 – 1967 793.8	61.8	4	7	7	3
												Period 1968 – 1984 551.2	42.9	4	7	7	3

In the dry season, all these sites are affected by the Harmattan, a hot dry wind with a strong drying action.

APPENDIX V

ADDITIONAL CONSIDERATIONS FOR STATES AND DONORS

During presentation of the project, some highly pertinent comments were made, which, although they have no impact on the project's design or justification, deserve to be brought to the attention of the states concerned and the interested donors. They may be summarized as follows:

- In any area of action, we must never overlook the traditonal knowledge of the rural population which has accumulated for centuries and has not been sufficiently explored.
- Because of the length of time required for any forest experiment and the patience needed to win the support of the people, the present project must continue much longer than the first 5-year period undertaken: it would be highly desirable to obtain from the donors a commitment, at least moral, to long-term financial support.
- Although by definition the project has a strictly silvo-pastoral objective, we must never lose sight during its performance of the other aspects implied, especially agricultural development.
- Its silvo-pastoral definition implies in this respect the involvement at the state level of several ministries (Waters and Forests, Livestock, Agriculture, Planning, etc.); it appears essential to take all necessary measures to ensure the overall multidisciplinary coordination of such an enterprise, which in any case seems essential to the proper conduct of the project.
- The states must also take all measures to guarantee an extension role after the end of the project.
- As the current tendency is to let the rural population profit more and more from the products of the forest, it would be beneficial to organize these rural people as rapidly as possible, in light their new responsibilities towards the forests, into such bodies as cooperatives, associations, or ad hoc groups that would allow them to take action collectively.
- To facilitate the allocation of responsibilities, from a different point of view, the states should study as soon as possible some profound changes to administrative, fiscal, and silvicultural regions which are generally poorly adapted to the desired evolution.

THE MANAGEMENT OF INDIGENOUS TREES AND SHRUBS FOR THE REHABILITATION OF DEGRADED RANGELANDS IN THE ARID ZONE OF NORTHERN KENYA

H.F. Lamprey
Senior Woodland Ecologist
MAB Kenya Arid Lands Research Station (KALRES)
P.O. Box 147, Marsabit, Kenya

CONTENTS

		Page
Section I:	Introduction	125
Section II:	Background and supporting information	127
Section III:	Objectives	130
Section IV:	Description of the Project	131
Section V:	Work plan and timetable for MAZIT, Kenya	135
	Project Budget	138

SECTION I INTRODUCTION

1.1 Introduction

Eight years of research on woodland ecology carried out by he UNESCO Integrated project in Arid Lands (IPAL) in northern Kenya, together with an enquiry into the prospects for arid zone forestry, have brought to light the nature of woodland degradation (as one aspect of desertification), its main causes and also some guiding principles for woodland management, described in the IPAL Management Plan for Western Marsabit District (IPAL Technical Report A-6, Part II).

A fundamental principle of woodland management in the arid zone is determined by the low and extremely variable rainfall which results in a very low success rate in tree planting. The combination of favourable conditions which are necessary for the successful growth of seedlings and sapling trees in the arid zone occurs every twenty to thirty years, which tends to make tree planting, especially with exotic species, impractical except on a very small scale in the immediate vicinity of localized water where the small trees can be irrigated. Under natural conditions stands of indigenous trees and shrubs become established in favourable years and may have the opportunity to grow to maturity if the climate and other environmental factors prove to be favourable. The relatively rare incidence of such advantageous conditions results in the occurrence of evenage stands frequently separated by intervals of between fifteen and forty years depending on the species and the recent climatic history of the region.

In addition to the constraints imposed by the climate, the success of a natural stand of indigenous trees or shrubs depends upon the degree of exploitation by human and livestock populations. With the increasing pressure on vegetation caused by growing populations of people and animals, woodland and shrubland communities are commonly prevented from achieving maturity and may be held in a stunted condition and eventually killed by excessive browsing and cutting. Nevertheless, it is an important characteristic of most of the indigenous trees and shrubs in the arid zone that they will tolerate repeated heavy browsing and burning, even to the extent of having their aerial parts removed year after year, while their rootstocks continue to grow with each season's regrowth of twigs and foliage. The studies of woodland and shrubland size-class structure over several thousand square kilometers of arid northern Kenya occupied by nomadic pastoralists, show that a large part of the general decline of the tree and shrub communities is due to the suppression of regeneration by browsing livestock. Simultaneously, especially within a few kilometers of settlements, the concentration of people, with their growing demands for firewood and building and fencing materials, results in the almost total destruction of trees and shrubs in an ever-increasing area around each village.

Against this background of degrading indigenous woodlands and shrublands, the IPAL programme set out to find practical methods to re-vegetate large areas of denuded rangeland. It became clear that tree planting, whether with indigenous or exotic trees, could not make more than a very slight impression upon the general widespread problem of tree destruction (although it is feasible and desirable in villages where individual plants can be watered and protected). It also became clear that a very great benefit could be obtained by the temporary protection of stands of indigenous trees in the seedling and sapling stages of growth. Experimental exclosure plots designed to provide demonstrations of the potential for woodland and shrubland regeneration showed that it is only necessary to exclude livestock (particularly goats) from a growing stand of young trees to enable them push one or two branches above the reach of goats, to enable the whole stand to grow to maturity. The results of protecting existing indigenous tree seedlings across the rangelands as a whole, but also within the villages, are probably hundreds of times more productive in re-afforestation in the arid zone than attempts to plant trees.

A further advantage that was found in the use of indigenous trees as compared with even the most drought-adapted exotic species was that when both were planted experimentally, in the same area, the exotic species (Prosopis chilensis, P. juliflora and Parkinsonia aculeata) did not survive drought years, whereas several indigenous species, notably Acacia tortilis, A. senegal, did survive.

There is possibly no need to stress the importance of trees and shrubs in the economy of the pastoralist people of Africa. Trees provide firewood; they provide materials for the construction of houses and livestock enclosures and they provide browse for the livestock upon which the pastoralists are almost wholly dependent for their subsistence. In addition to these three essential contributions to the pastoral economy, trees are virtually a necessity as providers of shade, a very important factor in the survival of cattle, sheep and goats in the arid zone. Trees are valued for fruit, and other useful edible and medicinal products, for fibre for rope making, and for the gum of certain Acacia species, including the gum arabic of commerce. The role of the leguminous tree species, so abundantly represented in the arid zone in Africa by the genus Acacia, in the maintenance of soil fertility through the process of nitrogen fixation should also be stressed as well as the reduction of soil erosion and desiccation which woodlands and shrublands provide.

The management recommendations have been adopted in principle by the Government of Kenya, but their implementation will largely depend upon donor funding. This project proposal presents a relatively inexpensive programme of woodland and shrubland management designed to rehabilitate large areas of rangeland in northern Kenya.

1.2 Title of Project

The Management of Arid Zone Indigenous Trees. (MAZIT).

1.3 Project Number

(To be provided).

1.4 Scope

Implementation in Western Marsabit District, (the Rendille homeland) of the woodland component of the resource management plan, developed by the UNESCO Integrated Project In Arid Lands (IPAL).

1.5 Priority Area

Arid Land Pastoral Ecosystems in north-eastern Africa, covering specifically the Rendille tribal area of Marsabit District, Northern Kenya.

1.6 Implementation

Kenya Arid Lands Research Station.

1.7 Cost of Project

U.S. $516,000 for 3 years.

1.8 Duration

36 months: commencing June 1986.
completion June 1989.
N.B. Extension beyond 3 years will be advantageous.

SECTION II BACKGROUND AND SUPPORTING INFORMATION

A. Justification of the Project

2.1 Research, survey and experimental management undertaken by IPAL in northern Kenya since 1976 have provided a wealth of data and explicit management plans on most aspects of land-use and economy in the region, including range and woodland management, upon which to establish a programme of natural resource management.

2.2 The woodland management component provides specific recommendations for the rehabilitation of degraded tree and shrub communities in the region.

2.3 Considerable liaison has been established with the Rendille people and their local chiefs which is already the basis for cooperative management activities in several fields of development and, on a pilot project scale, localized management of woodlands.

2.4 The IPAL Management Plans for western Marsabit District have been thoroughly reviewed by the Review Mission (1983) and adopted by the District Development Committee for implementation when funding is made available.

2.5 Background information on the ecological degradation and desertification which is taking place in northern Kenya (as in other regions of north-eastern Africa and the Sahelian Zone) through excessive exploitation of the vegetation by humans and livestock, has been provided in numerous descriptions to be found in IPAL Technical Reports and elsewhere. It is sufficient for the purpose of this project document to summarize the problem as follows:

2.6 A large part of northern Kenya is degraded and the processes of desertification have reached an advanced stage. Northern Samburu provides an example of seriously degraded country. In the vicinity of Mt. Kulal, Marsabit and Ngurunit in western Marsabit District, the productivity of the land has deteriorated but appears to hold considerable scope for gradual recovery if appropriate management practices are introduced. The potential for rehabilitation of the extensive degraded rangelands and woodlands has been demonstrated by the unexpected degree of recovery that has taken place in the vegetation and also the build up of top soil in fenced experimental plots at several sites in the IPAL study area, where protection has been provided over a period of six to eight years.

2.7 Serious interest has been expressed by several donor agencies in supporting certain components of the IPAL Management Plan implementation in western Marsabit District. Although it was hoped that the whole integrated implementation operation would be funded by one donor, it has become clear during 1985, that this is unlikely, but that the whole programme of management activities can be undertaken with each component activity supported by an appropriate agency. The Woodland Management component needs support.

2.8 Although the Project is to be undertaken in northern Kenya, there is no doubt that the experience gained so far, and the practical application of that experience in management activities, will be appropriate for many regions in the arid zone of Africa. This applies particularly to the Woodland Management component. It is anticipated that Woodland Management practices proposed here could make a valuable contribution to the control of desertification throughout the arid zone.

2.9 The Kenya Arid Lands Research Station (KALRES), which has been established in Marsabit through the cooperation of the Kenyan and West German Governements and UNESCO, is intended to provide a permanent base for the scientific monitoring of the environment of the region as well as continuing advice on all aspects of resource management.

Five field stations, situated at Gatab, Olturot, Kargi, Ngurunit and Korr, provide accommodation and basic working facilities for scientists and extension officers, across the project area.

2.10 A body of technical field assistants has been trained by the IPAL project from among the Rendille pastoralists and some of these men are available for employment as Woodland Management Assistants.

B. Provision for Government follow-up

2.11 It is anticipated that the Government of Kenya will eventually assume full responsibility for the operation of all components of the integrated management operation, including the Woodland Management component within three to five years. Starting with a pilot pre-extension project with its scope limited to the Rendille tribal grazing lands, it is expected that the scope will expand progressively to cover management of the range and livestock resources of Marsabit District, adjacent districts and eventually the whole arid region of Kenya. Depending upon the success of the initial management phase, further international assistance will be sought for the long term support of the expanded project.

C. Other related activities

2.12 The project should not be considered as an isolated initiative concerned with one aspect of man's interactions with arid zone ecosystems in Kenya, but, through its association with KALRES, should be clearly viewed within the broader perspective of activities for improving the productivity of arid lands and the rehabilitation of degraded areas in these zones. The project will continue to increase its links with the various studies and management activities that are being undertaken or planned by other international organizations (e.g. UNEP, FAO, UNESCO) or by bilateral agencies.

Steps will also be taken to ensure close co-ordination with other relevant projects in Kenya, including the Kenya Rangeland Environmental Monitoring Unit (KREMU). Working relations will also be maintained with the Universities of Nairobi and with field activities sponsored or undertaken by international organizations, such as those operating within the framework of UNEP-FAO Programme for the "Ecological Management of Arid and Semi-arid Rangelands" (EMASAR) and those that are developed in pursuance of the recommendations adopted by the United Nations Conference on Desertification (Nairobi, 1977).

SECTION III OBJECTIVES

3.1 Project long term objectives

3.1.1 The main long term objectives are to develop a system of land use which will reverse the present trend of degradation and establish sustained production within the livestock economy in Marsabit District at a level which is sufficient to provide for the needs of the growing and increasingly sedentarised population.

3.1.2 The project aims to follow the management guidelines prepared by IPAL for the Rendille grazing lands by carrying out a carefully co-ordinated programme of development and use of land, water and vegetation resources, of animal husbandry, of regulated livestock distribution and stocking levels, and of improved marketing.

3.1.3 The implementation of the management guidelines will require considerable flexibility in order to accommodate to several inevitable variables in the ecological and socio-economic circumstances characteristic of the arid zone. In particular, the overriding effects of the highly variable rainfall and the resulting variations in plant and animal productivity, with successive drought periods, must be taken into account in long term planning, both from the standpoint of ensuring the continuing supply of essential resources for the people and from that of preventing the environmental degradation which is prevalent during periods of drought.

3.1.4 The breadth of disciplines involved in such an integrated management programme will call for the co-operation of several specialized agencies and departments. The supervision and specialized monitoring and evaluation for the programme as a whole and for the Woodland Management component in particular can be provided by KALRES.

3.2 Immediate objectives of the woodland programme

3.2.1 To arrest the current decline in the tree and shrub populations and to ensure an optimal sustained production of wood and forage for the long term benefit of the pastoralist people of the region and of the country as a whole.

3.2.2 To provide alternative means for the fencing of livestock as a substitute for the thorn tree night enclosures which are the main cause of tree destruction in the region.

3.2.3 To provide the means to disperse the harvesting of firewood into the woodlands across the region as a whole instead of concentrating the collection in the vicinity of settlements as is the present custom, which is causing the spreading areas of tree destruction around the villages.

3.2.4 To increase the rate of recruitment of indigenous trees and shrubs to the mature tree populations.

3.2.5 To increase the economic productivity of the indigenous woodlands through the development of tree product marketing as a contribution to the diversification of the present livestock-based economy.

3.2.6 To undertake the regulation of tree harvesting for all purposes.

3.2.7 To establish the growing of indigenous trees and shrubs where ever possible, (e.g. near villages and wells) for fuel, livestock enclosures and experimental gum arabic and Commiphora resin production.

3.2.8 To implement alternative fencing construction programme, including the use of live hedges using indigenous shrub species.

3.2.9 To organize the collection of Acacia fruits for supplementary livestock fodder in the dry season.

SECTION IV DESCRIPTION OF THE PROJECT

4.1 Summarized description of the project

4.1.1 The project will operate in Marsabit District, Kenya, with the primary aim of introducing and implementing an integrated scheme of land-use management, designed to arrest desertification and to promote ecological and social rehabilitation in northern Kenya.

4.1.2 The Project comprises a programme of closely integrated management activities in which the research results obtained by IPAL will be applied through the implementation of the IPAL 1983 Management Plan for West Marsabit District in the tribal grazing lands of the Rendille people.

4.1.3 In the course of implementing the initial stages of the management plan, operational activities involving practical range, woodland and livestock management will be carried out cooperatively with the Government of Kenya and will be managed as a pre-extension programme of the Kenya Arid Land Research Station (KALRES).

4.1.4 The operation of the Project will be undertaken with the assistance of a team of international specialists working with counterpart professional staff of the Government and locally trained field assistants who will, in due course accept responsibility for the project's management activities. Depending upon the degree of success during the initial phase, further international long-term financing will be sought.

4.1.5 The initial main emphasis of the project will be the implementation of the pilot range and woodland management scheme (to be integrated with livestock management), in the Rendille grazing lands in western Marsabit District.

4.1.6 The scheme will involve the organization of the rotational use of rangelands and woodlands, based upon previously defined eco-climatic zones, recent and current rainfall patterns, water supplies, estimated current carrying capacities (dependent upon recent rainfall) linked to recent land use.

4.1.7 The woodland component of this programme will employ rotational use and systematic temporary protection from felling, lopping and browsing to ensure that woodlands and shrublands are permitted to regenerate and to achieve optimum levels of wood and browse production as sustained yields.

4.1.8 In order to provide semi-permanent livestock night enclosures without further excessive exploitation of indigenous trees, Commiphora cuttings will be planted to make live hedges. The need for such live hedge enclosures is greatest in the vicinity of settlements and water supplies.

4.1.9 For the same purpose dry stone wall enclosures will be constructed where there are adequate supplies of suitable stone.

4.1.10 In order to provide firewood without further reducing the tree and shrub populations in and around the settlements, a scheme for harvesting systematically the abundant dead Acacia reficiens and A. tortilis trees which are dispersed through the woodlands will be established. The collection of building poles will be managed. An animal transport system for carrying the firewood and building poles will be organized (as described below).

4.1.11 In order to diversify the present livestock-based economy and make the indigenous woodlands as productive as possible, the systematic harvesting of gum arabic from existing stands of Acacia senegal trees, accompanied by suitable tapping techniques, will be organized. The possibility of planting A. senegal to increase gum arabic production should be investigated.

4.2 Regulation of wood harvesting

4.2.1 Recognizing that the immediate annual requirement for wood for livestock night enclosures (bomas) and firewood for the 12,900 Rendille people in the project area are estimated as:

livestock enclosures: 38,700 tonnes;
firewood: 1,935 tonnes;

the provision of these quantities should be ensured by the Project until effective substitutes are found, but management should also ensure that these quantities are not substantially exceeded.

4.2.2 Wood collection for boma construction should be permitted under certain specific conditions:

a. where alternative night enclosures or construction materials are not made available;
b. that trees are cut only in areas specified by the woodland officers in accordance with the management plan;
c. that the trees cut are of species and sizes specified by the woodland officers, also in accordance with the management plan;
d. Woodland officers would ensure that wood for boma construction would be harvested from a limited number of woodland blocks;
e. Dead wood for fuel would be collected without restraint in all areas.

4.2.3 Important principles, derived from the IPAL woodland research programme, which should determine the quantities of live wood to be collected are:

a. wood should only be collected from dead and mature trees;
b. live wood should only be collected where the biomass (dry matter) exceeds 2.5 tonnes ha^{-1};
c. the total wood collection should not exceed the annual production in any area. By limiting live wood collection to areas of 2.5 tonnes ha^{-1} minimum biomass, the annual collection of at least 100 kg ha^{-1} (including dead wood) can be ensured.
d. with the exception of dead trees, mature and well-grown Acacia tortilis trees should be specially protected in all areas, since this species constitutes a major source of (dead) fuel, fruit for livestock fodder, dropped leaves for sheep fodder and shade.

4.2.4 In areas where A. tortilis is traditionally lopped to provide livestock feed in the dry season, limited branch lopping may be permitted under the supervision of the woodland officers. As a guide to the permitted rate of tree lopping, each medium-size tree (crown diameter: 10-15 m) could have one branch of c. 10 cm diameter lopped every two or three years.

4.2.5 The relatively extensive Acacia tortilis woodlands of the Ngurunit and Ilaut areas constitute an area of special management, owing to the unusually high density of trees in the 20-30 year age classes. It is considered advantageous to thin these trees systematically, to provide additional space for the remainder and, also to obtain a supply of building poles of a convenient size. The management officer for the area would be required to supervise the systematic felling of a suitable proportion of these trees, sawing them into usable lengths and storing them for use in buildings and as firewood for distribution by the local Rendille management committee. (For details on these committees, see the section 'Organization of Rendille Range-Development Activities', IPAL Technical Report No. 6, Pt. II p. 597).

The upper branches should be used firstly to provide browse for livestock, secondly as livestock enclosure material and later as firewood for the Samburu and Rendille pastoralists at Ngurunit and Ilaut.

4.2.6 The mature Acacia tortilis woodlands of the Ndoto Mountain foot-slopes and along most of the watercourses in the plains, are in danger of dying out in the next 30 years as there is insufficient recruitment of young trees. This is due to the increasing impact of browsing goats and camels. A special protection strategy is needed to enable A. tortilis regeneration to take place. (This strategy is currently being practised on a small scale in the Ilaut and Ngurunit areas).

Along the watercourses alternate 1-km lengths of riverine woodland will be closed to browsing animals for periods of four years each, to provide the opportunity for young trees to grow above the reach of goats. The 1-km lengths of river bank would be clearly marked by painting marks on the tree trunks. After a period of four years (if this proves sufficient) the protected banks would freed for use again and the formerly open stretches would be protected in their turn for four years.

4.2.7 In the larger blocks of A. tortilis woodland which flank the Ndoto Mts. the same principle will be applied but there the protection will be given to areas of approximately 1 km^2, similarly marked with paint on tree trunks.

4.2.8 The exclusion of browsing animals from protected woodlands is being achieved in the Ilaut and Ngurunit areas with the cooperation and authority of the Chiefs. It is proposed that this system be extended but with additional supervision of woodland guards acting under the instructions of the Chiefs and the woodland officers.

4.3 The regulation of livestock browsing of trees

4.3.1 Since the main objectives of woodland management in Marsabit District is to ensure the adequate regeneration of tree and shrub populations through the protection of young trees, browsing requires regulation across the woodlands and shrublands of the region as a whole, apart from the particular case of the Acacia tortilis woodlands already dealt with. Large areas of woodland and shrubland within 20 km of settlements and along the main routes of Rendille livestock movement are in danger of dying out due to lack of recruitment; young trees are being prevented from growing by heavy goat browsing. The results of protecting young trees can be seen in the enclosure plots at Kargi and Ngurunit, where very many have now grown above the reach of goats. It is necessary to establish rules which can be applied to any woodland unit needing temporary protection from goats and camels.

4.3.2 The use of woodland areas for browsing should be organized on a rotational basis which provides protection for over-browsed areas for periods of 4-5 years to enable young trees to grow beyond the vulnerable stage.

4.3.3 Where a balanced age structure has been restored or where a sufficient number of young trees has grown above 1.5 m high, a woodland should then be used for livestock browsing at a predetermined stocking rate. Tables are given in the IPAL Management Plan document (Pt. II, Tables 160 and 165) with initial estimates of suitable camel and goat stocking rates for each of the range management units in the Rendille area. Certain important woodland and large shrubland types of relatively small area may require management procedures that differ from the main range unit in which they are situated. For guidance, the management of such small woodland areas (particularly the riverine Acacia tortilis woodlands) the detailed woodland biomass, production and structure data are available. Provision for the special protection of these woodlands for the necessary period of rehabilitation will be made and the protection supervised by the woodland officers with the help of the Chiefs.

4.4 Logistic support for woodland management

4.4.1 As a principle, the Project will assist participating Rendille pastoralists to obtain wood for fuel and, where necessary, boma fencing material.

4.4.2 Firewood should be transported to settlements from the harvestable woodlands by camel.

4.4.3 Firewood should be cut up and piled in specified areas in the *Acacia tortilis*, *A. reficiens* and *A. mellifera* woodlands. It is anticipated that *dead trees will be sufficient to satisfy fuel* requirements. Management units 9, 10, 12, 18, 20 and 21 have a high enough production level to satisfy the requirements for all firewood and would also permit the cutting of live trees for boma construction within these units.

4.4.4 In all other management units tree cutting would normally be limited to the annual production level, but may be prohibited except for the collection of dead wood. In due course pastoralists occupying woodland areas where live tree cutting is prohibited should be provided with substitute fencing (dry stone walls, wire mesh or live hedges).

4.4.5 Camel transport of wood to settlements should be confined to the provision of firewood. No thorn fencing should be transported by camel. In settlements, all fencing should be live hedges, or constructed from wire mesh or rocks, depending on the availability of materials.

4.4.6 Camel transport of fuel and fencing material should be placed under the control of the woodland management officers in co-operation with the camel transport officers. The organization of the transport is described in Section G 5.5 (p. 594) of the IPAL Management Plan. The daily firewood requirements for the Rendille people are estimated at c. 5.3 tonnes. To provide this quantity daily will necessitate 53 camels each carrying 100 kg of firewood.

SECTION V WORK PLAN AND TIMETABLE FOR MAZIT, KENYA

5.1 July - December 1986

a. Appointment of Project Manager.

b. Project Manager's discussions with Government of Kenya.

c. Discussions with KALRES Chief Technical Adviser and his staff.

d. Familiarization with the project area in Marsabit District and its woodland and shrubland vegetation.

e. Discussions on integration with other aspects of management in the District.

f. Recruitment of Woodland Officers and Woodland Assistants and Guards.

g. Liaison with Chiefs.

h. Assembling equipment, vehicles etc.

i. Location and inspection of main management units.

j. Planning schedule for woodland management programme.

5.2 January to December 1987

a. Demarcation and marking of protected woodlands in western Marsabit District.

b. Training Woodland Officers in demarcation, mapping.

c. Meetings with Chiefs and elders to explain disposition of protected areas and obtaining agreement for their management.

d. Undertaking quantitative survey of woodlands and shrublands for purposes of assessing and controlling harvest and browse stocking rates.

e. Locating important firewood and timber resources mainly dead trees.

f. Establishing camel transport system to carry firewood to villages.

g. Assessing gum arabic potential and promoting gum collection.

5.3 January - December 1988

a. Continue marking protected woodland units.

b. Continue liaison with Chiefs and elders on the protection scheme.

c. Carry out quantitative survey of protected and unprotected areas to provide baselines for monitoring regeneration resulting from protection.

d. Supervise and monitor camel transport system, wood supplies and wood requirements in villages.

e. Examine prospects for improved gum arabic industry and for Acacia senegal plantations.

f. Co-operate with livestock management staff in assessing effects (if any) of excluding flocks and herds from the protected woodlands.

g. Make initial assessment of success of the woodland protection scheme.

5.4 January - June 1989

a. Prepare for transfer of woodland management scheme to Government staff.

b. Make substantive assessment of the success and benefits of the protection programme.

c. Hold meetings with Chiefs and elders together with counterpart Government staff to ensure the continuing interest and support of the local people the remaining year of protection in the first phase.

d. Hold demonstrations and seminars to show the results the woodland management programme to as many groups as possible: pastoralists, extension officers; teachers; range and forestry students; politicians; administrators; foreign visitors from other arid zone countries.

e. Final transfer of programme to counterpart Project Manager.

PROJECT BUDGET: July 1986 - June 1989
Management of Arid Zone Indigenous Trees (MAZIT)

Personnel	1986 $	1987 $	1988 $	1989 $	Total $
Project Manager	20,000	42,000	45,000	25,000	132,000
3 Woodland Officers	7,500	15,000	16,000	9,000	47,500
12 Woodland Rangers	6,000	12,500	14,000	8,000	40,500
	33,500	69,500	75,000	42,000	220,000
EQUIPMENT AND SUPPLIES					
Non-expandable equipment and vehicles	22,000	15,000	10,000	2,000	49,000
Supplies and construction	80,000	34,000	28,000	3,000	145,000
	102,000	49,000	38,000	5,000	194,000
RECURRENT OPERATING COSTS					
Maintenance and running of vehicles	8,000	18,000	20,000	10,000	56,000
Maintenance of equipment	2,000	5,000	6,000	1,000	14,000
Firewood and timber revolving fund	2,000	5,000	2,000	0	9,000
Contingencies	5,000	5,000	8,000	5,000	23,000
	17,000	33,000	36,000	16,000	102,000
	152,500	151,500	149,000	63,000	516,000

SELECTION AND GENETIC IMPROVEMENT OF INDIGENOUS AND EXOTIC MULTIPURPOSE WOODY SPECIES; INCLUDING SEED COLLECTION, HANDLING, STORAGE AND EXCHANGE

Forest Resources Division
Forestry Department
FAO, Rome, Italy

FAO acknowledges the assistance of O. Souvannavong and C. Cossalter
(Centre Technique Forestier Tropical, France)

TABLE OF CONTENTS

			Page
I	INTRODUCTION		140
	1.	Background	140
	1.1	Area under review	140
	1.2	Role of multipurpose species	140
	1.3	Role of tree improvement	144
	2.	Present status in selection and improvement of multipurpose species	145
	2.1	General	145
	2.2	Seed procurement	146
	2.3	Species and provenance selection	147
	2.4	Tree improvement and vegetative propagation	148
	2.5	Conservation of genetic resources	148
	2.6	Summary of present situation	148
II	PROJECT PROPOSALS		149
	1.	Justification	149
	2.	General description	150
	3.	Objectives and output	150
	4.	Activities	151
	4.1	Sub-Project 1: Exploration, Conservation and Provenance Seed Collection of Multipurpose Woody Species	151
	4.2	Sub-Project 2: Evaluation and Selection of Genetic Resources of Multipurpose Woody Species	152
	4.3	Sub-Project 3: Qualitative and Quantitative Improvement in Multipurpose Tree Seed Supplies	154
	4.4	Sub-Project 4: Coordination of Species and Provenance Selection of Multipurpose Woody species	154
	5.	Budget	155

ANNEX I List of basic equipment for a seed centre in the Sahelian and North Sudanian zones 161

ANNEX II Results of a survey on species priorities for the Sahelian and North Sudanian zones 163

I. INTRODUCTION

1. Background

1.1 Area under review

Woody species are grown or conserved for socio-economic or broadly ecological reasons, which may fall under the "production" category (for the production of wood, fuel, fodder, food, medicines etc.); or the "protection" category, aiming at the protection or improvement of the environment or local conditions of living (erosion control, maintenance of soil fertility, shade and shelter, etc.).

In arid and semi-arid lands, trees and shrubs generally combine productive and protective functions, and have a range of uses: they are almost always multipurpose.

The area included in this study, Africa south of the Sahara, is characterized by an average annual rainfall of less than 800 mm and a dry season lasting six months or more. It thus covers roughly three climatic areas:

- the Sudano-Sahelian areas, with an annual rainfall of 600 to 800 mm ($600 \text{ mm} < P < 800 \text{ mm}$)
- the Sahelo-Sudanese areas ($400 \text{ mm} < P < 600 \text{ mm}$)
- the Sahelo-Saharan areas ($200 \text{ mm} < P < 400 \text{ mm}$).

The Sudano-Sahelian area is characterized by natural formations such as savanna woodlands and savanna shrublands, and by predominant farming activities combined with sedentary animal husbandry (the agricultural zone).

The Sahelo-Sudanese and Sahelo-Saharan areas are characterized by natural formations of the steppe and savanna-shrubland types. The land is mainly used for animal husbandry as farming activities are limited to the best soils and are dependent on the availability of water supplies. The production of gum arabic plays a major role in the economy of certain Sahelian areas.

1.2 Role of multipurpose species

The areas under review are subject to a number of constraints, such as:

- relatively scarce resources (soil nutrients, water);
- high exposure to adverse climatic conditions (drying winds, wide temperature differences between day and night etc.);
- great fragility (susceptibility to erosion, precarious equilibrium of natural plant formations);
- considerable fluctuations in a major production factor: rainfall.

Because of these major constraints, past development efforts, particularly within the agricultural sector, have largely focussed on the more productive lands within the countries included in this study. In view of the vast extents of arid lands; their vulnerability; and their history replete with records on drought, crop failures and widespread human suffering, such policies must be re-examined and efforts increased to introduce appropriate land management and development systems in low rainfall areas. Trees and shrubs have a major role to play in this development.

Experience to date in trying to alleviate existing problems has shown that under arid and semi-arid conditions a crucial step consists in defining and implementing production systems that, by their nature, safeguard the long-term potential of the resources and the resource base. This may mean that options which, in the short term, are more profitable, must be discarded. This will be the case if they lead to greater susceptibility of the environment to adverse factors and to climatic fluctuations.

Past experience in tree planting in dry-zone Africa has clearly shown that long-term requirements can best be met by land utilization systems which combine farm crops, perennial multipurpose woody species and animal husbandry. Greater importance should therefore be given to integrated development projects covering e.g. whole watersheds, than to conventional, sectoral projects. In these integrated projects, agroforestry techniques will play an important role. Multipurpose woody species will play a predominant part; their main functions will be the following:

- in protection of productive lands:
    - stabilization of shifting lands
    - erosion control
    - shelterbelts and windbreaks;
- as a component in sound land use planning, in combinations of woody species, agricultural crops and animal husbandry (live fences and enclosures; fodder);
- in maintenance and restoration of soil fertility:
    - improved fallowing
    - permanent mixture of trees and crops (e.g. Acacia albida, Parkia biglobosa, and P. clappertoniana); or row planting of trees mixed with the growing of crops;
- in improvement of living conditions:
    - shade trees near huts and in villages
    - shelterbelts;
- in the production of goods for local consumption and marketing: timber; wood for posts, poles and fuel; fodder and food (fruits, nuts, roots, leaves, buds, shoots etc.); medicines; gums, resins, tannins; artesaneries, etc.

If species promoted can serve a number of different purposes simultaneously, they will be more easily accepted by local people. Thus, timber and wood should be considered to be only one of many products, sometimes only a by-product.

In his book on the Sahel, "Trees and Shrubs", H.J. von Maydell presents synthesis of the utilization of a number of dry-zone woody species and points out that every one of the 114 species reviewed is multipurpose.[1/]

A great number of woody species in the climatic zones under consideration is presently exploited on a non-industrial scale. There are also cases where the woody vegetation plays a major role in the economy of a district or a country, such as in the case of the production of gum arabic. In addition, more intensive management of woody vegetation or of trees and shrubs is sometimes traditionally practised in bush-fallow or agroforestry systems; some traditional uses are mentioned below.

Acacia albida: this species is combined with crops in a well-known traditional production system of Central and Western Africa; it improves soil fertility and yields rich fodder as well as wood.

Acacia nilotica: (ssp. nilotica, ssp. adstringens, ssp. tomentosa), yields fodder, tannin and wood. A. nilotica ssp. adstringens is occasionally planted in villages as a shade tree and for the production of tannin. Subspecies tomentosa grows in heavy soils in the flood-prone zones along major rivers; it can reach large size and can thus be a valuable source of timber.

Acacia senegal: the major source of gum arabic and a very important commercial species. It is also an important source of fodder. In the Sudan, a traditional bush-fallow system comprises twenty-five year cycles, in which farm crops and improved fallows of A. senegal (used for gum production) alternate. Regeneration of A. senegal is ensured as the seedlings are protected by the farmers and receive the benefit of agricultural tending during the four to five year agricultural cycle. After this period, the productivity of the soil generally falls below desirable levels for agriculture; and the Acacia seedlings, which start shading out the crops, are given preferential treatment over crops.

Acacia seyal: yields excellent wood for charcoal, but is seldom used as firewood as insects attack it soon after it is cut. It is also exploited for its gum, although the quality of the gum is lower than that of A. senegal. A. seyal is, further, a source of fodder.

Acacia tortilis (ssp. tortilis, ssp. spirocarpa, ssp. raddiana): a species of major importance in animal husbandry areas; it yields fodder as well as firewood.

Adansonia digitata: has many uses (food, pharmaceuticals, rope) and is thus a highly appreciated species in the Sahel, in spite of the fact that its wood is usually not used.

[1/] von Maydell, H.J. (1983). Trees and Shrubs in the Sahel. Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), Eschborn (Germany).

Balanites aegyptiaca: is used for its fruit, wood and as a source of fodder. It is occasionally planted for shade and in live hedges.

Borassus aethiopium: a palm in which every part of the plant has its own use. The stem yields building materials which are resistant to decay; the fruit and seeds are used as food; the sap is collected for the preparation of an alcoholic drink; and the leaves are used in basket weaving.

Parkia biglobosa and P. clappertoniana: grown in combination with farm crops in areas where the annual rainfall generally exceeds 700 mm. Their fruit is widely used as food. Their role as soil improvers is less clearly established than in Acacia albida.

Sclerocarya birrea: highly appreciated as a provider of shade. It yields an edible fruit; leaves that are used as fodder during the dry season; and wood for the manufacturing of tools and utensils.

Butyrospermum parkii (syn. Vitellaria paradoxa): found at the Southern edge of the Sudano-Sahelian area and grown in combination with farm crops. The edible "butter" derived from its fruit is an important product in some countries.

Prosopis africana: found at the southern fringe of the Sudano-Sahelian area, yields excellent timber or wood for joinery, as well as very good firewood. It is also used for fodder and a producer of pharmaceuticals. It is the only African species in the genus Prosopis.

Other species, such as Acacia mellifera, Euphorbia balsamifera and Leptadenia pyrotechnica, are of local important for live fences and in the stabilization of drifting sands.

Among introduced species, the most widely used ones in this region are Azadirachta indica and Prosopis juliflora, followed by Eucalyptus camaldulensis.

Azadirachta indica: originating in Asia, is planted mainly for shade or in row plantings, including windbreaks. It provides firewood, poles and a very good timber. In its area of origin, oil and an insecticide are produced from this species.

Prosopis juliflora: originating in Central and South America, is planted for stabilizing shifting sands and as shelterbelts. It yields a good quality firewood; its pods provide valuable fodder. In certain Sahelian countries where it was introduced long ago, it has adapted so well that it can become weedy under favourable conditions. Other introduced species of the genus Prosopis have also shown some early promise in Sub-Saharan areas (P. chilensis, P. pallida, P. cineraria).

Many other, less-used, multipurpose species are potentially interesting; these include Anogeissus spp., Albizzia lebbeck (shade, wood, fodder), Parkinsonia aculeata (shelter, fodder); Tamarindus indica, Ziziphus mauritiana, Hyphaene spp., Phoenix spp. etc.

A better understanding of the limitations of using conventional plantation species in the dry areas has led to efforts to diversify the species used in tree planting programmes, using traditional land utilization systems such as the ones quoted. These systems should be further developed through adaptation of modern technologies and lessons learned in handling and developing genetic material of other woody species.

1.3 Role of tree improvement

Over the past decade, there has been a marked degradation in the Sahelian and North Sudanian zones, both in the environment and in the productive potential. This is due to complex causes which are generally linked to rapid growth of the population which has led to over-exploitation of the environment: in farming areas new land is cleared at ever-increasing rates and the soil is left fallow for relatively shorter periods, whilst the pasture grounds suffer from serious over-grazing.

If the natural vegetation is not too badly degraded, it can frequently be regenerated through the application of appropriate management methods. To rehabilitate badly degraded areas it will generally be necessary to supplement management measures with planting trees and shrubs of known adaptability to prevailing environmental conditions; acceptable to the local populations; and suitable for the purposes defined at the outset of the development programme. Tree planting is also necessary to supplement goods and services provided by the natural vegetation, as a response to increasing pressures from population and livestock.

Generally speaking, the prerequisite for a tree improvement programme is plantation forestry. As soon as seeds or other reproductive materials are collected, plants raised and plantations artificially established, there is a chance to select and improve. A considerable amount of research and its application into practice has been carried out on a global scale in selection and improvement of industrial species such as pines and eucalypts; however, similar work has only recently started on a limited scale on optimal utilization of genetic resources of multipurpose species of mainly local importance.

Irrespective of the type of plant under consideration, wise utilization of genetic resources and their improvement to meet actual or potential needs for goods and services presuppose knowledge on their biology, variation and variation patterns; and the adaptability of intra-specific genetic variation to a range of environmental conditions, levels of technology and silvicultural treatments.

Genetic variation does not necessarily manifest itself in situ; therefore taxonomic and genecological exploration followed by systematic sampling throughout the area of natural distribution, and evaluation in field trials over a range of potential planting sites, are of fundamental importance and should form the basis for any investment - in time, effort and funds - in more advanced improvement activities: choice of the seed source (provenance) will generally give the largest, one-time gain ever achievable.

The practical importance of systematic exploration and testing has been convincingly demonstrated through a number of internationally coordinated species and provenance trials. The earliest of these trials were started in the mid 1960s using provenance seedlots of Eucalyptus camaldulensis, an Australian species which for decades has been widely planted as an exotic, for the provision of fuel, shelter, posts, poles and pulpwood. The results from the trials, established on 32 sites in 18 countries, showed that the potential gains in productivity which can be achieved simply by the selection of the best-adapted provenances for prevailing environmental conditions, could amount to several hundred percent: the difference in yield between the best and the worst provenance within this same species was in these trials 300% in Northern Nigeria and 800% in Israel, at about one-third of the estimated rotation age. Similarly, highly encouraging and rather spectacular results seem to be forthcoming from presently on-going exploration/evaluation of *Acacia* and *Prosopis* species, coordinated by FAO.

Such results have, in addition to their practical value in drawing up programmes for both conservation and utilization of the species in question, served to underline the urgent need for systematic action in other dry-zone species, a need compounded by increasing degradation of the environment in arid areas, increasing fuelwood shortages and the growing investments in fuelwood and other dry-zone plantations, which, at present, are generally established with seed of unknown origin and quality, from the most readily available sources.

The recognized and partly overlapping steps in a successful genetic resources programme are (i) exploration, (ii) collection of seed for testing and for conservation purposes, (iii) evaluation, (iv) conservation *in* and *ex situ*, and (v) utilization, i.e. use of semi-bulk and bulk quantities of seed or other reproductive materials; and improvement and breeding. Other activities will include training, the dissemination of information, over-all coordination and most importantly - application of research results into practice.

2. Present Status in Selection and Improvement of Multipurpose Species

2.1 General

When preparing the present document, the general biological and organizational principles outlined in the previous section were kept in mind and countries in the areas covered were visited for on-the-spot discussions on on-going research and development programmes in seed procurement and tree improvement; existing facilities; plans for the future; and possibilities, ways and means to strengthen on-going activities through regional and sub-regional cooperation between countries with similar interests and priorities.

A general finding was that the countries visited had, over the past years, paid increasing attention to the planting of trees and shrubs; more emphasis than ever before was being given to local, multipurpose species; little was known about the biology, genetic variation and requirements of these species due to their fairly recent inclusion into planting programmes and the relatively modest means available for research; availability of quality seed was a bottle-neck in many of the planting programmes. Inadequate availability of seed was often coupled with scarce information on seed handling and treatment, and subsequent wastage of this valuable resource. As documentation on seedlots used was more often than not unavailable, it would not in the future be possible to re-procure seed from those provenances which had proved to be well-adapted and to avoid those which had undesirable characteristics; in this latter case, a species was often considered non-suitable, as a whole, which might be a completely wrong conclusion. Non-availability of information on collection sites and number of trees collected from also rendered the advisability of further breeding, through conventional or higher technology, an uncertain investment.

Ten out of the 16 countries covered by the present study have a specialized department or institution for forestry research[1]. Generally, countries like Kenya - which has a long-standing forestry tradition in the humid areas - have carried out relatively more research also in the arid areas than those countries which do not have any longstanding forestry tradition.

2.2 Seed procurement

The unavailability of seed of high physiological and genetic quality is often a bottle-neck in forestry development. It is an important asset to have a specialized department to help supply the highest possible quality reproductive materials, taking into account all available knowledge of the species in use (selecting seed stands in the right provenances; establishment of seed orchards; high collection standards).

A Seed Centre was established in 1983 in Burkina Faso, and this Centre has subsequently been upgraded to a Seed Department (Direction des Semences Forestières); the Seed Department cooperates with the forest research institute, IRBET/CTFT[2], in species exploration and evaluation; and applies strict standards in seed collection and handling. It serves both development projects and research in the country and in some neighbouring countries.

The establishment of the Seed Department and coordination of its work with IRBET/CTFT has, thus, had a decisive, positive effect on exploration, conservation and evaluation work in the country. It has, furthermore, helped alleviate the problem of quality seed supplies to development projects.

In addition to the Direction des Sciences Forestières in Burkina Faso, seed sections exist in Ethiopia, Kenya, Nigeria, Tanzania and Senegal. The seed sections in the four first mentioned countries presently provide seeds for species planted in both humid and dry zones, with some emphasis on the former. Simple seed storage facilities are, in addition, available in the Sudan.

High priority by the Government is given to the establishment or improvement of seed centres in Cameroon, Mali, Niger and Mauritania, and some plans have recently been drawn up for action in this field in these countries.

---

[1] Burkina Faso, Cameroon, Ethiopia, Kenya, Mali, Niger, Nigeria, Senegal, Sudan, Tanzania.

[2] Institut de Recherches en Biologie et Écologie Tropicales/Centre Technique Forestier Tropical.

2.3 Species and provenance selection

Relatively early, large-scale planting programmes were carried out in countries such as Burkina Faso, Niger, Nigeria, Senegal and the Sudan, but species selection has, until recently, concentrated almost exclusively on exotic species, such as Eucalyptus.

There is, however, a marked increase in interest in species/provenance testing and in local, multipurpose species over the past years in all the countries included in this study. In addition to the FAO coordinated species and provenance trials of Acacia and Prosopis mentioned earlier, in which Senegal and Sudan participated since their inception in 1981 and a number of other countries have recently joined, species and provenance tests of fodder and fuelwood species - especially of the genera Acacia and Prosopis - have been carried out individually by a number of countries since the mid 1970s; both indigenous and introduced species are being compared on a range of sites. Systematic exploration of the natural distribution of local species is also underway in some countries, notably Burkina Faso,[1/] Cameroon,[2/] Mali[3/] and Niger[4/].

Comparative provenance tests of local species in the region were first established of Acacia senegal - a species of considerable economic importance for some countries - in the Sudan and in Senegal in 1974. Provenances of A. senegal included are from Chad, Niger and Sudan. Progeny testing of A. senegal has, subsequently, also been started in the Sudan. Results from these latter efforts have not yet, however, been processed and evaluated.

In the species/provenance testing of local and introduced species started in the mid 1970s, Acacia tortilis ssp. raddiana and A. senegal seem to stand out in performance, when considering fodder production.

In looking for species that could adapt to the difficult conditions in the Sahel, attention has been often been focused on introduced species originating in other areas with similar ecological conditions in other parts of the world. Thus, since 1973, 50 Australian Acacia species have been tested on various sites in Burkina Faso, Cameroon, Niger, Senegal, to a lesser extent in Mali, and more recently in the Cape Verde Islands and Mauritania. Results from these tests preliminarily indicate that, with an annual rainfall of more than 600 mm in continental areas, and more than 400 mm in coastal areas, the following species are potentially suitable:

[1/] Acacia albida, A. nilotica, Butyrospermum parkii, Parkia biglobosa and other native species.

[2/] Mainly A. albida.

[3/] Mainly A. albida.

[4/] A. albida, A. nilotica, A. senegal, A. tortilis, Balanites aegyptiaca, Ziziphus mauritiana.

- for protection and erosion control: A. coriacea, A. schlerosperma and A. bivenosa;
- for wood and fodder production: A. holosericea, A. trachycarpa and A. tumida.

The above, preliminary results need to be verified through additional, more detailed testing. For this purpose CSIRO, Australia, and CTFT carried out a joint seed collecting mission in 1984 in the continental, dry tropical areas of Australia; 38 Acacia species and a total of 78 provenances were collected for testing. Also another major group of potentially interesting exotic species, of the genus Prosopis, is being studied in the Sudan, where Prosopis chilensis was introduced as early as 1919. Comparative testing has been started with provenances of P. glandulosa, P. spicigera (= P. cineraria), P. juliflora and P. velutina. The local land race of P. chilensis has proved to be the best adapted to date.

2.4 Tree improvement and vegetative propagation

In the broad field of tree improvement very little has, to date, been done on individual tree selection and breeding. Seed stands have been established in few countries, seed orchards in even fewer. Some work is underway on vegetative propagation of native species, both in the region itself and outside it (Sudan, Senegal, France etc.). These efforts are, to a certain degree, coordinated amongst some West and Central African countries (Burkina Faso, Cameroon, Mali, Niger and Senegal particularly), to achieve greater efficiency. Wider cooperation would lead to even more reliable results of wide interest.

2.5 Conservation of genetic resources

From the point of view of conservation, the degradation of natural woody vegetation in the Sahelian and North Sudanian zone as a whole has resulted in severe genetic impoverishment. No systematic surveys have yet been carried out on the extent of threats to individual species, but the situation seems critical for instance for Acacia nilotica ssp. tomentosa along the Senegal river and in Ethiopia's Rift Valley; and for Acacia senegal in large parts of its natural distribution range.

The status of genetic resources of species of actual or potential socio-economic value in the area needs to be better assessed in order to initiate urgently appropriate conservation measures in and ex situ. Such measures are a prerequisite for future utilization and improvement of these species.

2.6 Summary of present situation

Thus, in summary (i) there is a recent, manifested interest in the exploration, collection and testing of local, multipurpose species and provenances in the areas under review, but efforts have to date been relatively modest due to limited means; (ii) only Burkina Faso presently has a Seed Department, specialized in collection and handling of arid zone seeds, which has sufficient means to be truly influential as regards the quantity and quality of seed supplies for development projects in parallel with adequate research capability, and thus the only one in the Sahelian and Sudano-Sahelian zone which is able to supply adequate quantities of high quality seed of multipurpose species for the dry areas. This centre should receive all support and encouragement possible.

The situation in the countries in the region could be much improved by strengthening the small seed units in Senegal and Sudan; and by directing activities in the seed centres in Ethiopia, Kenya, Nigeria and Tanzania to better match the recent, increased emphasis on plantation forestry in arid and semi-arid lands in these countries.

Efforts to establish seed sections or departments in other countries should also be encouraged and supported; availability of specialized knowledge in seed collection, handling and storage is of fundamental importance for any tree planting programmes on a larger scale and should be an integral part of them.

It is to be noted that all presently existing seed sections form part of the Forestry Research Departments of Centres, except for the one in Burkina Faso which is part of the Forestry Service.

Close cooperation is called for between research and development in this field, especially where the parent departments of the existing or proposed seed centres and the one in charge of development programmes, differ.

The countries visited all agreed that efforts in the fields of seed collection and handling; species and provenance selection; and tree improvement, need to be urgently stepped up. They also agreed that close collaboration between the countries is essential to learn from each others' experiences, to maximize use of available funding, to avoid duplication of effort and to speed up evaluation and improvement. Some degree of cooperation presently exists between West and Central African countries - wider cooperation would be highly desirable.

II. PROJECT PROPOSALS

1. Justification

The cost of establishing plantations in developing countries, at 1980 cost levels, ranged from 200 to 2000 U.S. dollars per hectare. Costs of plantation establishment will, in theory, be the same regardless of the quality of the seedlings used; the selection and use of optimal species and provenances will, on the other hand, increase potential production manifold, and these gains can be compounded by intra-population selection and breeding. Investment in soundly based selection and breeding programmes has proved to be one of the most cost-effective activities in industrial plantations and - based on evidence to date - will be so also in multipurpose species and community plantings: gains likely to be achieved can be substantial, and they are of a lasting nature.

When viewed in the light of the projections of future planting programmes, and considering potential returns, the investments urgently needed in intensive species and provenance research; research on seed handling and storage; and on breeding and conservation in the Sahelian and North Sudanian zones are - in relative terms - minor.

Field activities in seed collection; and in evaluation and selection of genetic material of multipurpose tree species, are already underway, at varying intensities, in all countries included in the present study. Networking and strengthening of links between institutes involved is thus a logical step to strengthen action in systematic exploration, conservation and wise utilization of dry-zone arboreal species - the main-stay of life in the Sahel.

Plants are no respecters of political boundaries: coordination of activities across boundaries is thus essential in genetic resources work.

2. General Description

The document lists four "projects". These should be viewed as components of one larger umbrella project, rather than individually. Exploration and collection of seed logically precedes - and partly overlaps with - evaluation, and such work, in turn, must form the basis for individual selection and breeding. Systematic exploration, followed by evaluation to determine intra-specific variation patterns, is also a prerequisite for efficient conservation in and ex situ. The exploration/collection phase is, in the present document, estimated to last 3 years, overlapping during its last year with the evaluation phase. Overall coordination is budgeted for a 5-year period. Improvement of infrastructure and facilities; and research on seed handling, storage and treatment, should run in parallel for the full 5 years, taking the region as a whole. This is true also for the conservation activities, in which action should start with those species in which some basic information already is available; or which are in need of urgent attention. In this context, it should be noted that the concept of conservation embraces both preservation and utilization: the key to conservation is appropriate management, and conservation must always be an integral part of development.

Although the present project proposal is for a total period of 5 years, follow-up activities and further improvement of genetic material developed during this period will require continuing efforts for a number of years to come. Further assistance needs and precise programmes should be specified at the end of the first 5-year period.

3. Objectives and Output

The present umbrella project with its four component projects has the following general objectives.

1. To determine the best adapted and the most productive woody planting material for development projects in the Sahelian and North Sudanian zones, including gathering of information on variation, genotype x environment interactions and silvicultural requirements of promising species. Desirable characteristics of the species include ability to efficiently contribute to environmental protection, restoration and improvement; and high productivity as regards specified products such as wood, fuel, food, fodder, gums, resins and tannins.

2. To make available, for use in tree planting programmes, cumulatively better genetic materials of high physiological quality; at the same time ensuring, through appropriate breeding strategies, the maintenance of a broad genetic base in the species improved.

3. To conserve, in and ex situ, species and populations threatened with genetic impoverishment or extinction.

4. To assist in building up know-how, infrastructure and facilities for carrying out sound work in the broad field of forest genetic resources.

5. To catalyze and facilitate cooperation and the exchange of information and genetic materials.

In summary, thus, the project would lead to (i) increased knowledge on native and some exotic species, their distribution, variation and biology; (ii) the availability of high-quality seed of an increased range of species for evaluation and for planting in development programmes in a range of conditions and providing a range of specified goods and services; (iii) coordinated programmes on seed collection, handling, storage; and tree improvement and breeding, in the countries in the Sahelian and North Sudanian zone - including increased dissemination of information and dialogue; and (iv) conservation of vitally important genetic resources for present-day and future use.

4. Activities

4.1 Sub-Project 1: Exploration, Conservation and Provenance Seed Collection of Multipurpose Woody Species

Tropical woody species usually cover extensive areas, and genetic variation developed in response to ecological variation in them is generally large.

Once the geographic distribution range of a species has been determined, seed collection should be carried out systematically for genecological studies, covering the different ecological zones of its occurrence. As a general rule, genetic variation is largest in optimal growing conditions; however, outlying populations often contain valuable genes for adaptability to conditions such as extreme temperatures for the species, drought or salt resistance, and it is therefore important to include such populations in the collection work.

Representative stands will be identified in each zone for testing and use. These should be large enough for maintenance of a broad genetic base, and be well identified and demarcated. Seeds are collected from a minimum of 25 trees growing at least 100 m from each other, so as to reduce the possibilities of relatedness between mother trees; and to ensure proper representation of existing, intra-specific genetic diversity.

In exploration and seed collection operations, it is proposed to focus mainly on some local species which are presently used in the region as providers of wood, fuel, fodder, food, gums and resins. These species tentatively include the following:

- Anogeissus spp.
- Acacia albida
- Acacia nilotica ssp. adstringens, spp. nilotica, ssp. tomentosa
- Acacia seyal
- Acacia senegal
- Acacia tortilis ssp. raddiana, ssp. synocarpa, ssp. tortilis
- Balanites aegyptiaca
- Ziziphus mauritiana

- Butyrospermum parkii
- Parkia biglobosa
- Tamarindus indica
- Palms, such as Borassus, Hyphaene, Phoenix.

The distribution ranges of many of the species cover all the countries included in this study, and are of known value of them. Ideally, all countries should thus participate in their exploration and collection. The aim would be to collect, over a three-year period, some 250 provenance samples; this should include up to thirty provenances of the most widely spread species, in each of the larger countries like Senegal and the Sudan. Seed of some of Acacia species has already been collected within the framework of, for example, the FAO coordinated arid zone genetic resources project and these could complement the collections now proposed.

Provenances from countries outside this study, within the natural distribution range of the species, should be obtained through seed exchange or through special collection expeditions carried out in collaboration with the host countries. Provenance seedlots of potentially important exotic species - i.e. species found outside the region in the genera Acacia and Prosopis, for example - should also be procured along the same lines.

The seedlots should be sent to one or two well-equipped seed centres in the region; it will be the task of these centres to carefully collate available collection data; to ensure proper storage; and to despatch seedlots for field testing. A contribution will be made towards covering part of the manpower and operating costs.

Regarding conservation of endangered species and provenances, exact needs in genetic conservation can be accurately determined only after preliminary exploration, which will enable us to take stock of the threats to populations. When feasible, in situ conservation is the most desirable strategy. However, in most cases complementary ex situ activities should be applied by seed collection and storage, or the establishment of ex situ conservation stands in more favourable areas under less pressure, or in areas where protection can be more easily assured. When collecting for conservation purposes, collection will be done randomly, from a large number of trees, applying the same spacing standards as in provenance collections (i.e. trees collected from should be at least 100 m apart).

Exploration, collection and conservation should be coupled with studies on phenology, biology and breeding systems of the species concerned. Such studies will form the basis for their conservation and wise utilization.

4.2 Sub-Project 2: Evaluation and Selection of Genetic Resources of Multipurpose Woody Species

Experiments can be established as soon as the exploration and seed collection phase has been finalized (2nd/3rd year).

In species for which the utilization aspects are well-known, evaluation will focus on their performance within various production systems, considering production of a range of goods and services. Under the present umbrella project, it is proposed to assess the seedlots collected within the framework of three collaborative networks:

- *Network 1*: Selection and improvement of *Acacia senegal*, mainly for the production of gum arabic; the study can, subsequently, serve as a model for research and development of other gum-producing species such as *Acacia seyal*, *Sterculia* spp. etc.

- *Network 2*: Selection and improvement of *Acacia albida*, for use mainly in agroforestry systems. As was the case for the previous network, the study can serve as a model for other, similarly utilized species, e.g. *Balanites aegyptiaca*.

- *Network 3*: Selection of improvement of other species, for end uses specified at the outset of the programme. These species will include those indigenous to the region as well as introduced species. It should, however, be kept in mind that the decision to regenerate with non-native species and to include them in large-scale plantation programmes must always be taken with great care and only after comparative testing with alternative, native species. Conservation of representative samples of the native species must always be given high priority if exotics are introduced on a large scale, as a back-up and for security.

In the first network, *Acacia senegal* provenance collections will be supplemented by progeny collections from exceptionally heavy gum producers found in natural stands or in plantations. Testing will determine the relative importance of genotype and environment in gum production; as well as modes of inheritance. Clonal tests should also be established in connection with such studies - this will include research on vegetative propagation.

In the *Acacia albida* network, experiments should be established under conditions prevailing in traditional production systems in which this species is used, i.e. on farmland, in combination with crops. Assessment should be made of all functions the tree performs as, e.g. a soil improver and a producer of fodder. This is not an easy task, but is nonetheless essential as, to date, little quantitative information is available e.g. on the relationship between early growth and the production of pods; or soil improving effects.

In contrast to *A. albida* and *A. senegal*, for which testing conditions can be clearly defined as functions of their traditional uses, in exotics and in poorly-known local species, adaptation and growth must be assessed in a range of different environmental conditions and production systems. Special emphasis should be given to silvo-pastoral systems; in these *A. tortilis* is, according to present knowledge, a leading species along with *A. senegal*. A range of provenances of these two species should, therefore, be included in species/provenance trials in which possible alternative species are tested.

Within the three networks, a total of some 200 ha of experimental plantings per year is foreseen over 3 years. This is a magnum effort which no country could hope to achieve alone; the need to share the work between all cooperating countries is thus evident, and coordination of the trials is essential to enable subsequent, overall conclusions to be drawn from them.

4.3 Sub-Project 3: Qualitative and Quantitative Improvement in Multipurpose Tree Seed Supplies

Genetic and physiological quality of reproductive materials is one of the major factors determining success in tree planting. Establishment of a specialized section dealing with forest seeds is an efficient way to achieve good physiological quality of the seeds collected; and to ensure that collection is carried out from phenotypically desirable stands, maintaining a broad genetic base.

It is proposed, within the framework of the present project, to strengthen existing seed centres such as those in Senegal and Sudan; and to assist in the setting up of Seed Centres in the Cape Verde Islands, Somalia and possibly Mauritania. It should, in this connection, be noted that seed collection and storage units are presently being set up in Mali, Niger and Cameroon and that an excellent centre, which should be fully supported within the framework of the project, already exists in Burkina Faso.

It is important to acknowledge that when the objective of a seed centre includes the supply of large quantities of seed to on-going planting projects, it fulfills a development role, even if administratively and technically it falls in the interface with research, from which most seed centres originate. Thus, the centres should be technically managed by staff with a research orientation, but be fully supported by development agencies directly benefitting from their work.

The role of a seed centre will be further increased if users of tree seeds, such as nursery staff and plantation managers, understand the reasons for, and benefits to be derived from, use of well-documented, high-quality seed and do not consider restrictions to harvest in poorly performing or small plots as obscure administrative regulations only. It is thus necessary to reinforce efforts in training to include these groups, and to improve general awareness of basic, practical rules of genetics. Heredity and the negative effects of inbreeding are very concrete concepts that can be easily illustrated.

4.4 Sub-Project 4: Coordination of Species and Provenance Selection of Multipurpose Woody Species

The overall coordination of the proposed activities will be ensured by an expert based within the region, preferably in one of the centres responsible for the storage of seed. The "Over-all Coordination" sub-project includes a large component for facilitating contacts and cooperation between national institutes in the region.

The tasks of the Coordinator will be:

- To provide leadership, catalyze action and cooperation between institutes and technically assist less experienced countries; this will include the organization of two or more workshops. The first workshop would be held early in the project on exploration, conservation, seed collection and studies on phenology and biology of species included. During this workshop, information will be exchanged on programmes planned or underway in cooperating countries; and on methodologies to be applied. The second Workshop will be held at the end of the exploration/collection phase, to take stock of progress made and to agree upon and coordinate the establishment of field trials in the countries.

- To act as a focal point for seed exchange programmes both within and outside the networks outlined on p. 21; facilitate the dissemination of information; and contribute to national and local training sessions on seed collection and tree improvement, organized for seed centre staff and the users of tree seeds. He should also assist in the raising of awareness at technical as well as political levels of the importance of work in the genetic resources field; and -if so requested - in the formulation of request for multilateral, multi-bi or bilateral assistance for activities in this field at the country level within the region.

5. Budget

The outline of activities in sub-projects 1 to 4 correspond to the budget outlines below.

- Sub-Project 1: Exploration, Conservation and Provenance Seed Collection of Multipurpose Woody Species.
  Duration 3 years. Estimated cost $ US 965 000 (pp. 155-156).

- Sub-Project 2: Evaluation and Selection of Genetic Resources of Multipurpose Woody Species.
  Duration 3 years. Estimated cost $ US 1 248 000 (pp. 157-158).

- Sub-Project 3: Quantitative and Qualitative Improvement in Multipurpose Tree Seed Supplies.
  Duration 5 years. Estimated cost per country $US 375 000 (pp. 158-159).

Sub-Project 4: Coordination of Species and Provenance Selection of Multipurpose Woody Species.
Duration 5 years. Estimated cost $US 1 092 000 (pp. 159-160).

The figures given reflect estimated funding requirements from international donor sources to support national and regional programmes. They do not include local costs, which are generally covered by the countries themselves as a counterpart contribution.

It should also be noted that figures and outlines will need to be adjusted to meet the requirements of donors approached; the budget estimates do not, presently, include overheads and agency costs, inflation factors etc.

Sub-Project 1: Exploration, Conservation and Provenance Seed Collection of Multipurpose Woody Species

Objectives

Exploration of the natural ranges of *Anogeissus* spp., *Acacia albida*, *A. nilotica*, *A. seyal*, *A. senegal*, *A. tortilis*, *Balanites aegyptiaca*, *Ziziphus mauritiana*, *Butyrospermum parkii*, *Parkia biglobosa*, *Tamarindus indica*; *Borassus*, *Hyphaene* and *Phoenix* spp. Provenance collections for the establishment of field trials. Conservation of endangered species and provenances.

Activities

- To survey the natural range; to preliminarily propose for collection, provenances and stands representative of the species;
- To collect provenance seedlots;
- To treat and store the seedlots pending the establishment of comparative field tests;
- To conserve, in situ and ex situ, endangered species and provenances;
- To carry out phenological and biological studies of the species.

Inputs

- Collection equipment;
- Funding for field trips (exploration);
- Funding for field trips (collection);
- Procurement of provenance seedlots from countries outside the network;
- Contribution towards the operation of seed centres in charge of handling and storage of collected seedlots;
- Contribution towards genetic conservation measures;
- Contribution towards phenological and biological studies.

Duration

3 years.

BUDGET

		US $
-	Collecting equipment	100 000
-	Surveying (1 year): Operation of vehicles	80 000
	Local allowances	50 000
-	Collection (2 years): Operation of vehicles	160 000
	Local allowances	100 000
	Minor equipment; handling and despatch of seeds; occasional labour	50 000
-	Procurement of species and provenances from outside the network	60 000
-	Contribution towards the operation of seed centres storing the seedlots	60 000
-	Conservation:	
	in situ	60 000
	ex situ	100 000
-	Contribution towards phenological and biological studies	100 000
-	Miscellaneous	45 000
		965 000

Sub-Project 2: Evaluation and Selection of Genetic Resources of Multipurpose Woody Species

Objectives

- Provenance and individual selection of Acacia senegal to improve the yield of gum arabic;
- Provenance selection of Acacia albida as part of agroforestry systems;
- Species and provenance selection for provision of a range of goods and services, with special reference to forage and fuelwood production.

The above objectives are long-term, however, preliminary selection based on adaptation and early growth can be started after approximately 3 years of testing. Replication of the trials in time and place will enhance their value.

Activities

- Organization and coordination of comparative trials within the networks;
- Survey and mapping of the trial sites;
- Establishment of the trials (over 3 years);
- Submission of the establishment reports;
- Tending and maintenance of the trials;
- Evaluation and measurements;
- Submission of reports on early results.

Inputs

- Funding of survey and mapping of trial sites;
- Funding of establishment and maintenance of the trials;
- Contributions towards costs of evaluation;
- Contributions towards preparation of early reports on the trials.

Duration

3 years.

Sub-Project 2: contd.

BUDGET

	US $
- Despatch of seeds	30 000
- Survey and mapping of trial sites	60 000
- Establishment of trials and early maintenance (approx. 600 ha over 3 years)	850 000
- Evaluation and measurement (including field trips)	150 000
- Analysis of data and reporting costs	100 000
- Miscellaneous	58 000
	1 248 000

Sub-Project 3: Qualitative and Quantitative Improvement in Multipurpose Tree Seed Supplies

Objectives

- To meet the requirements of seeds of multipurpose trees and shrubs with good quality stock.

Activities

- To establish or strengthen seed sections in countries with large on-going or planned plantation programmes in the Sahelian and North Sudanian zones;
- Survey, selection and delimitation of seed production areas;
- Collection, handling, storage and distribution of seeds;
- Training of field staff.

Inputs

- Buildings for the housing of the seed section (construction of new buildings or extension/adaptation of existing ones);
- Equipment and vehicles;
- Training of the Head, Seed Section;
- Technical assistance through consultancy services;
- Selection and demarcation of seed production areas;
- Continuing training of field staff in:
  - basic knowledge of genetics and its application in seed stand and plus tree selection;
  - seed collection and handling techniques.

PROJECT 3 (contd)

Duration

5 years.

BUDGET (for one Seed Section)	US $
- Training of Head, Seed Section	40 000
- Buildings, incl. seed store	60 000
- Equipment:	
. Office	35 000
. Laboratory	15 000
. Seed collection, storage and handling	50 000
- Vehicle	18 000
- Training session for field staff (20 participants)	15 000
- Operational costs over 3 years, including selection and demarcation of seed production areas, seed collection, storage and despatch	80 000
- Technical assistance (consultancy services, 6 months over 3 years)	40 000
- Travel	4 000
- Miscellaneous	18 000
	375 000

Sub-Project 4: Coordination of Species and Provenance Selection of Multipurpose Woody Species

Objectives

- To catalyze and coordinate action for exploration, collection and testing of multipurpose trees and shrubs.

Activities

- Organization and workshops, one at the beginning of the project on exploration, collection and conservation; one when exploration has been completed, on evaluation of the genetic material available for testing;

- Establishment of links between cooperating countries, with special reference to the publication of a bulletin twice yearly; and organizing visits and study tours.

- The establishment of contacts with organizations outside of the cooperating countries for the procurement and exchange of seeds;
- Assistance to cooperating countries in the choice of experimental sites and in the design of experiments;
- Assistance to cooperating countries in the preparation of proposals for multilateral, multi-bi or bilateral assistance in the genetic resources field;
- Training of field staff;
- Preparation and submission of general report on exploration and collection;
- Preparation and submission of a general report on establishment of trials and early results;
- In collaboration with cooperating countries, preparation for the submission to donors of proposals for follow-up activities at a regional level.

Duration

5 years.

Inputs

- Funding of the coordinator and general operating expenses;
- Funding of Study Tours and travel of network members and coordinator;
- Funding of workshops on exploration, collection and species and provenance selection in multipurpose trees and shrubs.
- Funding of Newsletter.

BUDGET

	US $
- Coordinator (5 years)	500 000
- General operating expenses (incl. hire of office space)	150 000
- Vehicles and their operation	45 000
- Travel of coordinator (6 months per year):	
Travel costs	50 000
Daily Subsistence Allowance	75 000
- Workshop on exploration, collection and evaluation	50 000
- Workshop on establishment of field trials and evaluation	50 000
- Travel and Study Tours of network members	80 000
- Dissemination of information	40 000
- Miscellaneous	52 000
	1 092 000

ANNEX I

LIST OF BASIC EQUIPMENT FOR A SEED CENTRE IN THE SAHELIAN AND NORTH SUDANIAN ZONES

Description	Characteristics	Example of Type
Buildings		
- Office	10-15 m^2 (per unit)	
- Secretariat	15m^2 (approximately)	
- Laboratory	40m^2 (approximately)	
- Seed store (with cold room if necessary	30-50m^3	
Vehicles		
- Vehicle	Station wagon (4x2)	
- Seed collection	Pick-up truck (4x4)	
- Vehicle (1-2 depending on working programme)		
Laboratory Equipment		
* Precision balance	Precision 0.001g, capacity 440g	METTLER PC440
* Scales	Precision 0.1g, capacity 6kg	METTLER 6000
* Stove (for drying seed samples for determination of humidity)	Capacity 60 l, 40-220°C	
- Water distiller	Capacity 1l/h	
- Infra-red dryer (for rapid determination of humidity of small seeds)	Could be connected to precision balance	METTLER LP15B
- Binocular microscope	40 x enlargement	
* Petridishes (for germination tests of small seeds)		
* Germination boxes for testing large seeds	12x16x8cm (approximately)	
* Stove (for hot-water pretreatment of seeds)		
- Germinator (incubator)	Control of light and temperature (15-40°C)	
- Termohygrometer/recorder	-10- + 40°C, humidity 0-100%	
Collection and Treatment		
- Saws, secateurs		
- Pruning scissors (for cutting branches up to 6m height)		
- Sectional ladders (for reaching branches above 6m)	Aluminium, 1-3m elements	
- Sheets (cloth, plastic) to lay under trees collected (for gathering the seeds)		

Description	Characteristics	Example of Type
- Hay-rake (for gathering up the seeds)		
- Wooden netted boxes (for drying cones/seeds)	1x1m (approximately)	
- Large cloth-sacks (for transport of pods or cones)	Type used for cereals	
- Smaller cloth bags (for transport of seeds)		
- Mortars and pounders (for seed extraction (esp. for leguminous seeds)		
- Sieves for separation of seeds	Calibrated sieves, Ø315	
- Mechanical threshers (when traditional pounding and winnowing are insufficient)		
- Densiometric column for separation and cleaning small seedlots		South Dakota Blower
- Camping material for seed collection expeditions (camp beds, cooking utensils etc.)		
Storage and Despatch		
- Air-tight tins for seed storage	Plastic containers guaranteed air-tight, 20-30 l capacity	ETS MAUSER (Paris)
- Sets of shelves		
- Balance for small seedlots	Capacity 6kg, precision 0.1g	
- Scales for large seedlots	Capacity 60kg	
- Polythene-bag sealer for seedlots to be despatched		
- Thermohygrometer/recorder	0-50°C, 0-100% humidity	
Optional, in case of high temperatures and/or humidity, for medium or long term seed storage		
- Cold store	Modular; dimensions: 2.40x 5.20x2.80m; entry door 0.99x 1.88m; isolated floor	
- Refrigeration equipment	For cooling $35m^3$: power 2KVA, voltage 380V; cooler in function 18h/day approx., consumption 36KW/day approx.	
- Dehydration equipment and condensator for humidity control (30% inside the cold room)	Power $285m^3$, voltage 220V (monophase), 2150W/h consumption	

* Essential equipment

ANNEX II

RESULTS OF A SURVEY ON SPECIES PRIORITIES FOR THE SAHELIAN AND NORTH SUDANIAN ZONES

The survey that follows was carried out during the IUFRO Research Planning Workshop for Africa. Participants from countries in the region were asked to list indigenous or introduced multipurpose woody species considered of priority for selection and improvement programmes. Replies were received from all 14 countries represented, viz. Burkina Faso (BF); Cameroon (CA); Chad (CHD); Ethiopia (ETH); Gambia (GBE); Kenya (KE); Mali (MA); Mauritania (MTN); Niger (NI); Nigeria (NGA); Senegal (SEN); Somalia (SOM); Sudan (SUD); and Tanzania (TAZ).

A total of 116 different species were listed by the countries taking part in the survey. Some of the species most commonly mentioned are listed in the Table. (1) indicates highest priority given to a species, (2) indicates second highest priority.

Also some other species received a high, over-all priority rating, e.g. for the Sahelian and North Sudanian zones, Sclerocarya birrea, Tamarindus indica, Combretum glutinosum, Prosopis africana, Pterocarpus erinaceus, Parkinsonia aculeata, Combretum aculeatum, Casuarina equisetifolia (coastal areas); and for the North Sudanian zones, Khaya senegalensis, Albizzia lebbeck, Parkia biglobosa, Butyrospermum parkii, Leucaena leucocephala.

In addition, a number of species came out strongly on a sub-regional basis; and others were emphasized as being of great, local importance.

Species	BF	CA	CHD	ETH	GBE	KE	MA	MTN	NI	NGA	SEN	SOM	SUD	TAZ
					Species considered priority (1) by more than 75% of the countries									
Acacia albida	1	1	1	1		1	1	1	1	2	1	1	1	1
Acacia senegal	1	1	1	1		1	1	1	1	1	1	1	1	
					Species considered priority (1) or (2) by at least 50% of the countries									
Acacia nilotica var. adstringens	1	1	1	1		1		1	2	1		1	1	2
Acacia nilotica var. tomentosa	1	1		1					2	1	1	1	1	2
Eucalyptus camaldulensis	1	1	1		2		1		1		1	2	1	
Acacia seyal	1	1	2	1			2		2	2	1		1	
Balanites aegyptiaca	1	1	2			1	1	1			2	2	2	
Azadirachta indica	1	1	1	2		2	2		2		2	2	2	
Acacia tortilis	1			1		1		1			1		1	1
Ziziphus mauritiana	1	1	2			1		1	2			1		
Prosopis juliflora	1		2			2				2	1	1	1	

IMPROVEMENT OF WOODY PLANTING STOCK THROUGH MANIPULATION OF SYMBIOTIC MICROORGANISMS IN THE SAHELIAN AND SUDANO-SAHELIAN ZONES (SSSZ)

Y. Dommergues (CNRS/ORSTOM/CTFT)
J. Gorse (The World Bank)
B. Dreyfus, J.P. Colanna (ORSTOM)
S. Badji (Eaux et Forêts) Senegal
A. Niang (CNRF/ISRA) Senegal

1. BACKGROUND AND JUSTIFICATION

1.01 Background

In the Sahelian and Sudano-Sahelian Zones (SSSZ) most soils are of low fertility, often deficient in nitrogen and phosphorus and structurally fragile, with low humus content and poor water retention capacity. Because of these characteristics, such soils are most sensitive to over exploitation and vulnerable to erosion. Under the pressure of increasing population combined with drought spells, deforestation has spread over the last few decades, increasing the pace of desertification. The consequences are dramatic because in SSSZ, trees are not only the major source of energy (wood fuels and charcoal) but they greatly contribute to the welfare of the inhabitants by providing a variety of useful products as well as fodder for the animals and other forestry products, the so-called secondary products (fruit, gum, medicinal products). Moreover, it is well established that some species of trees behave as "soil improvers".

To improve such an alarming situation, forest development programs have been launched. Unfortunately, they have failed to achieve the expected results. The main reason is to be found in the lack of planting stock adapted to the harsh conditions of the SSSZ.

Two technologies can be adopted to increase simultaneously the tolerance of ligneous material to the harsh Sahelian and North Sudanian conditions and their growth rate: (1) selection and genetic improvement; and (2) manipulation of trees/shrubs and bushes, symbiotic microorganisms (nitrogen fixing symbiots and mycorhizal fungi). Whenever possible, these two strategies should be used simultaneously. It would not be advisable to adopt high technology, such as the manipulation of symbiotic mircoorganisms without first improving the planting stock. It is commonly believed that genetic selecting and improving of ligneous materials should be applied to the plant itself. In fact it is necessary to direct the genetic selection and improvement toward a better association of the plant with symbiotic microorganisms. This considerably increases the tolerance of plants of climatic as well as edaphic constraints.

(1) Selection and Genetic Improvement of Ligneous Material

Plant breeding has been responsible for much of the spectacular increase in crop yields in agriculture over the last 30 years, but tree breeding, especially as far as species native to arid and semi-arid countries are concerned, is still in its infancy. Tree breeding can, however, greatly contribute to an increase in plant growth rates, as well as resistance to some environment constraints, if the wide variation occuring within the same species is carefully exploited. To illustrate this variability, let us recall that Peter Felker of the Texas A & I University reported a 20-fold range in biomass productivity of Prosopis depending upon the individual specimen. So far, however, not enough attention has been paid to the possibility of genetic improvement of plants in function of their ability to associate themselves to symbiotic microorganisms. For example, the Dakar group (ORSTOM, CTFT, ISRA, CNRF, University) has shown that through clone selection, it was possible to double or even triple nitrogen fixation by Casuarina cariratifolia. It is worth mentioning in this respect that these various results were based on the exploitation of genetic variability of plants, either spontaneous (testing of superior plants, for instance) or artificially provoked (especially by tissue culture).

Once a better ligneous material has been obtained, it must be multiplied either with its seed or through vegetative multiplication. For practical reasons, this project is limited to vegetative multiplication.

The most important methods of vegetative propagation are based on the use of cuttings and tissue cultures.

The use of cuttings remains the most popular method. It is currently used in India and Thailand for Casuarina junghuhniana. This method has been greatly improved by CTFT in the case of Eucalyptus grown for industrial plantations. The cost is minimal (ca 10 cents of a US$ per tree). In Dakar, ORSTOM has developed a very simple method using a floating polystyrene board that holds the cuttings; rooting occurs within less than 3 weeks with Casuarina.

Tissue culture techniques, as a way to propagate clones of woody plants (this process is called micropropagation), are still mostly at the experimental stage. More research is required to adapt these techniques to large-scale use. One should note that, when they are perfected, micropropagation techniques will allow the production of thousands or even millions of plantlets from an initial explant harvested on a superior tree. The Dakar group has made some progress in the micropropagation of Acacia albida and is currently developing an original method for micropropagation of Casuarina. Obviously, micropropagation should be used only when cutting is difficult or impossible or when it produces a deficient ligneous material.

The potential of tissue culture techniques is not restricted to micropropagation. These techniques can be used for other purposes such as: disease elimination, haploid production, germplasm exchange, wide hybridization and mutant selection. One difficulty is related to the selection of variants obtained in the presence of imposed stresses (salt, drought, etc...) and hence resistant to these stresses. The ORSTOM laboratory in Dakar is currently exploring the possibility of using tissue culture techniques (in vitro fertilization, protoplast fusion) to transfer the stem-nodulating ability from stem-nodulating legumes (such as Sesbania rostrata or some Aeschynomene species) to non stem-nodulating legumes, thus equipping them better to overcome ecological constraints thanks to a high nitrogen-fixing potential and an increased tolerance to soil nitrogen (A number of stem-nodulated species of Aeschynomene thrive in Sahelian bottom lands during the rainy season. One of these species is a tree: Aeschynomene elaphroxylon, which produces good forage).

(2) Biotechnology of the Symbiotic Microorganisms

The symbiotic microorganisms (=symbionts=symbiotic endophytes) that are involved in associations with higher plants fall into four main categories: (1) Rhizobium, associated with many species of the Leguminosae family (plus the genus Parasponia); (2) Frankia, associated with actinorhizal plants (such as Alnus, Casuariana, Myrica); (3) Endomycorhizal fungi, associated with the vast majority of plants (annual and perennial), the most important endomycorhizal fungi being the vesiculo-arbuscular fungi or VA fungi (which form vesicules and arbuscules in the root cortex of infected plants); and (4) Ectomycorhizal fungi, associated with trees (e.g., Eucalyptus, or Pines).

Rhizobium and Frankia fix nitrogen from the atmosphere, thus providing the host plant with the nitrogen it requires when the nitrogen content of the soil is low or nil. Ecto- and endomycorhizae improve the supply of phosphorus to the host by drawing it from the soil around the roots and transferring it to the plant. Ecto- and endomycorhizae also enhance the absorption of trace elements in the soil which are not mobile, such as zinc and copper. It is recognized that mycorhizae play a major role in the absorption of water by plants, which explains why mycorhizal trees withstand the shock of transplantation better than non-mycorhizal ones.

A given tree, selected for its high performances (such as rapid growth, high N2 - fixing potential, tolerance to salt), may not fully express its potential in the field if limiting factors intervene. It is thus necessary to identify these limiting factors and to try to cope with them. In the semi-arid and arid tropics the main obstacles to the establishment and growth of trees are soil pathogens, nitrogen and phosphorus deficiencies, and drought, which is in turn often associated with excessive soil salinity. Soil pathogens can be eliminated by sterilizing the soil at the nursery level. The effects of phosphorus deficiency and drought are often significantly reduced by inoculation with mycorhizae. Nitrogen-fixing species can overcome a nitrogen deficiency if they are properly inoculated.

Eliminating soil pathogens through sterilization at the nursery level is an absolute necessity. A recent experiment carried out at Sangalkam, Senegal, showed that, 17 months after, the survival of Acacia holosericea seedlings was less than 37% if the nursery soil had not been sterilized, whereas it was almost 90% if the nursery soil had been sterilized. Sterilization at the nursery level is inexpensive and can be easily carried out using a multipurpose disinfectant such as Dazomet (a well-known nematicide).

A necessary adjunct to the preliminary sterilization of nursery soils is the inoculation of seedlings with the appropriate symbiotic microorganisms, either Rhizobium or Frankia (for N2-fixing trees) or endo-or ectomycorhizal fungi (for all tree species). Based on the results of previous experiments, we usually recommend inoculation N2-fixing trees with the nitrogen-fixing symbiont (Rhizobium or Frankia) and mycorhizal fungus (ecto- or endomycorhizal fungus) simultaneously. At the nursery level, this double inoculation generally has a spectacular effect, and improves tree growth markedly.

Applying these new technologies appears to be a most promising approach to overcome the difficulties hitherto encountered when attempting to develop reforestation projects in SSSZ. A number of field trials carried out in Senegal by ORSTOM scientists working in collaboration with CTFT and the Centre National de la Recherche Forestière (Institut Sénégalais de la Recherche Agricole) and the Direction Générale des Eaux et Forêts have clearly shown that the proposed approaches can be confidently recommended to assure the success of reforestation in difficult situations.

However, one should be well aware of the fact that the present level of technology development is still inadequate. The major reason is that basic research (on which applied development should be based) is not sufficiently advanced. The breakthroughs that occurred recently in the areas of plant tissue culture and the manipulation of symbiotic microorganisms must be further exploited and more research done. A tentative list of research priorities should include the following:

1. Genetic improvement of trees, using every tool available, including tissue culture techniques;
2. Improvement of the methods of cultivation of some difficult symbionts and improvement of inoculation techniques;
3. Development of appropriate methods for establishing and maintaining the plantations in association with livestock within the framework of the previously mentioned research themes (points 1 and 2), taking into account socio-economic problems that will be encountered when implementing the findings.

To reach these objectives, it is necessary to build:

a) a permanent network (PN) involving different SSSZ countries and relying on a preliminary coordinating unit (PCU).

b) a Central Research Institution (CRI). This will be either a single or multiple unit depending on ecological zones.

PN/PCU and CRI should be closely associated with institutions from more advanced countries.

1.02 Justification

The basic justification for the project is the need to develop our knowledge and know-how with regard to the genetic improvement of trees in conjunction with the manipulation of symbiotic microorganisms.

Achieving this goal obviously requires a sustained effort for at least more than a decade, first as mentioned in the previous paragraph to build up a permanent network providing the SSSZ nations with the necessary assistance in order to strengthen their capability to establish plantations according to the new technologies that will become available, second to establish a powerful Central Research Institution in charge of the research program that has just been summarized above.

The proposed project is a prerequisite to the implementation of any serious national programme of forest development because of the acute need to have plants with the best performance and most likely to adapt in the areas of protection and development of ground cover in the SSSZ.

The objective mentioned above directly relates to the declared policy of most of the SSSZ governments, determined as they now are to tackle the difficulties encountered in their efforts to fight desertification.

1.03 Special Considerations

(1) It is clear that the project's results will be of direct use to the different national agencies in charge of reforestation and agroforestry programs all the more so because socio-economic aspects of these results could be carefully examined in function of the development of scientific programs. It is not less obvious that the transfer of the project's results will require the development of a strongly coordinated action requiring the participation of each country concerned.

(2) The ORSTOM Laboratory in Dakar, in cooperation with CTFT and three Senegalese institutions (CNRD/ISRA, University and Eaux et Forêts), have already great experience in the field of manipulation of the root symbionts and of vegetative propagation of a number of SSSZ nitrogen fixing trees (such as Acacia senegal, A. nilotica, A. holosericea, A. raddiana, prosopis sp.). Thus there already exists a nucleus of know-how upon which the project can rely during the first stages of its functioning. This would not only play the role of a spring-board but also would warrant the success of the venture.

(3) Another favorable factor is the likely association of a number of laboratories from more advanced countries (e.g., USA, Europe). Some have already been identified: e.g., the research group led by P. Felker in USA or by A. Fortin and M. Lalonde of Laval University in Canada; the BSSF/CTFT[1] group at Nogent-sur-Marne (France). One should add here that this laboratory could

---

[1] Laboratoire de Biotechnologie des Systèmes Symbiotiques Forestiers Tropicaux (CTFT, Paris, France).

be later associated with an institution that would be sponsored by the City of Nice, France (Fondation Internationale de Biotechnologie Végétale de la ville de Nice). Private companies could be also involved in the venture. The role of these laboratories would essentially be a) to train periodically researchers from the SSSZ, and b) to conduct basic research to solve the practical problems raised by the selection and genetic improvement of ligneous plants and their symbiotic associations.

(4) We have already stressed the fact that a strongly coordinated action was required to achieve the goals that have been delineated. We have suggested above that this action could be entrusted to the care of a Central Research Institution (CRI) that should be established in one or several of the SSSZ countries as indicated at the end of paragraph 12. However, one should be well aware of the fact that this ambitious objective cannot be fulfilled at once. Thus we have proposed a time-table indicating the different preliminary steps to take before beginning the building of the Central Research Institution (see paragraph 31).

2. OUTPUTS

21 Purpose

211 Policy Statement

The main objective of the project is to coordinate the research, training and extension activities of SSSZ within the framework of genetic selection and improvement in association with the manipulation of symbiotic microorganisms of ligneous plants.

The project will devote a great deal of effort to the training of SSSZ scientists and technicians.

The project will also involve a number of important outputs in the area of genetic improvement of ligneous plants in association with the manipulation of symbiotic microorganisms:

(1) Establishment of a permanent network coordinating research activities between SSSZ nations and some more advanced countries;

(2) Exchange of information and know-how for the particular benefit of SSSZ; this will be obtained through direct communication, technical assistance and through annual workshops to promote direct contacts between researchers;

(3) Publication and dissemination of information on socio-economic problems encountered when conducting research; and description of solution proposed to solve these problems;

(4) Advice to participating governments and institutions in the following areas: identification of priorities and coordination of reafforestation programs including establishment and management.

212 Technical Considerations

The policy statement is based on results obtained in different tropical countries and especially in Western Africa by several institutions. The problem of desertification in the SSSZ and elements of a strategy for better resource management in these zones have been clearly presented in a World Bank report (no. 5210, February 19, 1985). This report includes an extensive list of references. The proposed technical approaches are mainly based on the work carried out in Western Africa by the ORSTOM group and by Texas A & I University and by Laval University.

The book on agroforestry edited by P. Huxley (1982) was found to be a most precious source of information. Other important documents from ICRAF have been also taken into account.

From this large set of data it was concluded the approach defined in para 11 is required to achieve successful reafforestation in SSSZ: (1) selection and genetic improvement of trees, using in particular tissue culture techniques; (2) proper manipulation of the symbiotic microorganisms (nitrogen-fixing symbionts and mycorhizal fungi); and (3) transfer of findings obtained by monitoring socio-economic experiments.

22 Outputs

The different types of output should be as follows:

221 Research

- Improving the methods for selecting individual trees with better survival, better growth rate and increased resistance to different climate and soil constraints, increased production of forage.
- Improving the methods for obtaining plants resistant to drought and salinity through tissue culture techniques.
- Improving the methods of vegetative propagation (cutting or micropropagation).
- Mastering the inoculation techniques at the nursery level through:
    - selection of best strains of nitrogen fixing symbionts, especially Rhizobium
    - selection of best ecto- or endomycorhizal fungi,
    - improvement of the procedures of inoculation.
- Improving the techniques of transplantation and establishment of plantations; spacing, weeding, fertilization (low applications of phosphorus fertilizer may be necessary in many circumstances).
- Evaluation of the cost of the new technologies.

- Evaluation of the impact on the people's welfare.

- Evaluation of the socio-economic constraints.

222 Training

Training of scientists should deal with four different fields:

- genetic improvement of ligneous plants,
- vegetative micropropagation and other tissue culture techniques,
- microbiology of symbiotic microorganisms,
- socio-economic problems.

223 Transfer of Knowledge and Extension

The transfer of results to the field practice and to the farmer requires the involvement of agronomist, herders and foresters, who should get information about the new techniques through workshops aiming at establishing contact with the researchers specialized in the new technologies.

With the help of researchers from the Central Research Institution, agronomists and foresters (1) would give proper advice to participating governments and national institutions, (2) would give the technical assistance required to implement the regional or local reforestation programs.

23 Program of activities

231 Research Program

Let us recall that the goal of the research program is to develop new forest development in order to restore the forest cover necessary (1) to protect the SSSZ against the insidious desertification process, (2) to increase the wood and fodder production in these zones to the benefit of the native populations.

232 Training of SSSZ Scientists

This training would be carried out in two phases:

- a purely academic training (1 or 2 years) in a university abroad;
- a more practical training (1-2 years) that would be achieved in SSSZ.

At the end of the training period, the scientist should defend a Ph D thesis in an African or foreign University.

233 Training of Technicians in SSSZ

Practical training and courses should be related to the following topics:

- Tissue culture techniques,
- Culture of symbiotic microorganisms and inoculation techniques,
- Nursery techniques,

- Techniques of establishment and maintenance of plantations,
- Techniques of estimation of wood and fodder production.

3. INPUTS

31 Policy Statement

Taking into account the outputs and activities described above, it appears necessary to proceed according to a two-stage program and to strengthen the scientific collaboration with specialized institutions from Europe or Northern America.

311 First Stage (year 1-3): Creating a Permanent Network (PN) Together with a Preliminary Coordination Unit (PCU)

311.1 Permanent Network

Some countries, for example Burkina Faso, Kenya, Senegal or Sudan, have already initiated investigations in the field of biotechnology applied to forestry or agroforestry systems. A first objective of the present project would be to strengthen the potential of these national institutions by establishing a Permanent Network (PN).

An important requirement for the national institutions participating in the PN is that each of them would be representative of a specific ecological region. Besides the institutions mentioned above, the PN would comprise a few intitutions from abroad, such as North American Universities, ORSTOM and CTFT/CIRAD and a specialized International Foundation such as that sponsored by the city of Nice (cf. paragraph 13).

The different programs carried out by the participants in the PN should be complementary and not compete with each other.

311.2 Preliminary Coordination Unit (PCU)

At the outset, the PN should be supported by a Preliminary Coordination Unit (PCU) with the following objectives:

- Coordinating the activities of the members of the network, especially initiating or participating in the establishment of the major joint research programs;

- Initiating and maintaining collaboration with the network involved in the exploration of genetic resource and more specifically in the collection of seeds;

- Contributing to the training of SSSZ scientists and laboratory technicians (this is a major issue);

- Initiating and carrying out specific research on a limited number of tree species (mainly but not only nitrogen-fixing species) that are currently known as the most promising ones.

It is suggested that the PCU be located at Dakar because there already exists an efficient research group with relatively developped facilities.

We have already mentioned that this group has already obtained promising results in the field of biotechnology applied to forestry and agroforestry problems. The group is composed of researchers from ORSTOM, Direction Générale des Eaux et Forêts of Senegal, Centre Technique Forestier Tropical (CTFT) associated with Centre National de la Recherche Forestière (CNRF) of Senegal and the University of Dakar.

312 Second Stage (year 4-5): Building the Central Research Institution (CRI)

The establishment of both PN and PCU proposed above is only a first step towards this goal. In order to go further, it is necessary to concentrate the efforts and the available resources. This aim can be achieved only through the creation of a powerful Central Research Institution (CRI), with enough qualified scientists and the proper facilities.

The location of CRI in one of the SSSZ countries should be decided within the 2 first years of the project so that enough time is available for building and acquiring the necessary scientific equipment and supplies.

During stage 2 the preliminary network (PN) established in the previous stage should be extended and comprise all the national institutions that are willing to participate and exhibit the desirable capabilities to contribute to the venture.

Since enough researchers and technicians will have been trained during the two first stages, CRI should be operational as soon as the building is completed.

313 Scientific Collaboration with Foreign Specialized Institutions

As suggested previously some institutions from Europe or Northern America associated in the PN and CRI should contribute to the training of the African scientists and the development of specific investigations especially in the newest research fields, as already indicated in paragraph 13.

It is hoped that the donors will contribute to the functioning of PN and CRI and the strengthening of the North-South collaboration for 10 years at least.

ANNEX I

TABLE I. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

Total Costs

			PY_1	PY_2	PY_3	PY_4	PY_5	TOTAL
	U	UC	Q	Q	Q	Q	Q	Q
1. Permanent Network (PN)			726	799	878	966	1 063	4 432
2. Preliminary Coordination Unit (PCU)			1 937	1 988	1 170	1 540	1 416	8 051
3. Central Research Institution (CRI)			-	-	5 594	6 035	3 962	15 591
TOTAL			2 663	2 787	7 642	8 541	6 441	28 074

ANNEX I

TABLE 2. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

I. Permanent Network (PN)

			PY_1		PY_2		PY_3		PY_4		PY_5		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
11. Infrastructure			-	-	-	-	-	-	-	-	-	-	-	-
12. Equipment			-	-	-	-	-	-	-	-	-	-	-	-
13. Personnel			-	-	-	-	-	-	-	-	-	-	-	-
14. Operation														
141. Training	Center	25	(6)	150	(6)	150	(6)	150	(6)	150	(6)	150	(30)	750
142. Travels & P. Diem	Center	25	(6)	150	(6)	150	(6)	150	(6)	150	(6)	150	(30)	750
143. Field experiments	Center	50	(6)	300	(6)	300	(6)	300	(6)	300	(6)	300	(30)	1 500
Total baseline costs				600		600		600		600		600		3 000
Physical contingencies 1/				60		60		60		60		60		300
Price consumption 2/				66		139		218		306		403		1 132
TOTAL AFTER CONTINGENCIES				726		799		878		966		1 063		4 432

1/ 10% on total costs including purchases of vehicles & salaries of personnel (including local technician, support staff & manual labor)

2/ PY_1 0.10 - PY_2 0.221 - PY_3 0.331 - PY_4 0.4641 - PY_5 0.61051

ANNEX I

TABLE 3. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

2. Preliminary Coordination Unit (PCU) - Summarized costs

			PY_1	PY_2	PY_3	PY_4	PY_5	TOTAL
	U	UC	Q	Q	Q	Q	Q	Q
21. Infrastructure			612	612	-	-	-	1 224
22. Equipment			231	100	6	175	6	518
23. Personnel			482	482	482	482	482	2 410
24. Operation			323	335	347	347	347	1 699
Total baseline costs			1 648	1 529	835	1 004	835	5 851
Physical contingencies			113	114	44	48	44	363
Price contingencies			176	345	291	488	537	1 837
Total After Contingencies			1 937	1 988	1 170	1 540	1 416	8 051

ANNEX I
TABLE 4. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)
2. Preliminary Coordination Unit (PCU/1)

	U	UC	PY$_1$		PY$_2$		PY$_3$		PY$_4$		PY$_5$		TOTAL	
			Q		Q		Q		Q		Q		Q	
21. Infrastructure														
211. Laboratory (800 m2)	m2	0.75	(400)	300	(400)	300	-	-	-	-	-	-	(800)	600
212. Green house (200 m2)	m2	2.	(100)	200	(100)	200	-	-	-	-	-	-	(200)	400
213. Library (100 m2)	m2	0.75	(50)	37	(50)	37	-	-	-	-	-	-	(100)	74
214. Office (200 m2)	m2	0.75	(100)	75	(100)	75	-	-	-	-	-	-	(200)	150
S/total Infrastructure				612		612		-		-		-		1 224

ANNEX I

TABLE 5. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

2. Preliminary Coordination Unit (PCU/2)

			PY_1		PY_2		PY_3		PY_4		PY_5		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
22. Equipment														
221. Laboratory	set	80	(0.5)	40	(0.5)	40	-	-	(0.25)	20	-	-	(1.25)	100
222. Green house	set	80	(0.5)	40	(0.5)	40	-	-	(0.25)	20	-	-	(1.25)	100
223. Library	set	20	(0.5)	10	(0.5)	10	-	-	(0.25)	5	-	-	(1.25)	25
224. Office	set	20	(0.5)	10	(0.5)	10	-	-	(0.25)	5	-	-	(1.25)	25
225. Vehicles														
· Tractor	unit	20	(1)	20	-	-	-	-	(1)	20	-	-	(2)	40
· FWD	unit	20	(1)	20	-	-	-	-	(1)	20	-	-	(2)	40
· Break	unit	15	(1)	15	-	-	-	-	(1)	15	-	-	(2)	30
· Sedan	unit	10	(4)	40	-	-	-	-	(4)	40	-	-	(8)	80
· Pick up	unit	10	(3)	30	-	-	-	-	(3)	30	-	-	(6)	60
· Motorcycle	unit	1	(6)	6	-	-	(6)	6	-	-	(6)	6	(18)	18
S/total Equipment				231		100		6		175		6		518

ANNEX I

TABLE 6. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

2. Preliminary Coordination Unit (PCU/3)

	U	UC	PY_1		PY_2		PY_3		PY_4		PY_5		TOTAL	
			Q		Q		Q		Q		Q		Q	
23. Personnel														
231. Direction														
· Chief (nat.)	m/y	10	(1)	10	(1)	10	(1)	10	(1)	10	(1)	10	(5)	50
· Deputy (nat.)	m/y	7	(1)	7	(1)	7	(1)	7	(1)	7	(1)	7	(5)	35
· AFD (nat.)	m/y	7	(1)	7	(1)	7	(1)	7	(1)	7	(1)	7	(5)	35
· Assistant (exp.)	m/y	75	(1)	75	(1)	75	(1)	75	(1)	75	(1)	75	(5)	375
232. Researcher														
· National	m/y	5	(3)	15	(3)	15	(3)	15	(3)	15	(3)	15	(15)	75
· Expatriate	m/y	75	(3)	225	(3)	225	(3)	225	(3)	225	(3)	225	(15)	1 125
233. Other staff														
· Technician (nat.)	m/y	3	(6)	18	(6)	18	(6)	18	(6)	18	(6)	18	(30)	90
· Consultant & Auditor	m/m	10	(5)	50	(5)	50	(5)	50	(5)	50	(5)	50	(25)	250
· Support staff & seasonal labor	m/y	1.25	(60)	75	(60)	75	(60)	75	(60)	75	(60)	75	(300)	375
S/total Personnel				482		482		482		482		482		2 410

ANNEX I

TABLE 7. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

2. Preliminary Coordination Unit (PCU/4)

			PY_1		PY_2		PY_3		PY_4		PY_5		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
24. Operation														
241. Maintenance of infrastructure	1	*	-	-	12	12	24	24	24	24	24	24	84	84
242. Vehicles														
· Tractor	4 200 km/y	9	(1)	9	(1)	9	(1)	9	(1)	9	(1)	9	(5)	45
· FWD	36 000 km/y	9	(1)	9	(1)	9	(1)	9	(1)	9	(1)	9	(5)	45
· Break	36 000 km/y	9	(1)	9	(1)	9	(1)	9	(1)	9	(1)	9	(5)	45
· Sedan	36 000 km/y	7	(4)	28	(4)	28	(4)	28	(4)	28	(4)	28	(20)	140
· Pick up	36 000 km/y	5	(3)	15	(3)	15	(3)	15	(3)	15	(3)	15	(15)	75
· Motorcycle	1	0.5	(6)	3	(6)	3	(6)	3	(6)	3	(6)	3	(30)	15
243. Infrastructure														
· Laboratory														
· Green house	(1)	250/y	(1)	250	(1)	250	(1)	250	(1)	250	(1)	250	(5)	1 250
· Library & office														
· Training & visit														
S/total Operation				323		335		347		347		347		1 699

* about 2% of existing building

ANNEX I

TABLE 8. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

3. Central Research Infrastructure (CRI) - Summarized Costs

			PY1		PY2		PY3		PY4		PY5		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
31. Infrastructure			-	-	-	-		1 250		1 475		375		3 100
32. Equipment			-	-	-	-		837		560		87		1 424
33. Personnel			-	-	-	-		865		865		865		2 595
34. Operation			-	-	-	-		968		969		972		2 909
Total baseline costs			-	-	-	-		3 920		3 809		2 299		10 028
Physical contingencies			-	-	-	-		282		313		161		757
Price contingencies			-	-	-	-		1 391		1 913		1 502		4 806
Total After Contingencies			-	-	-	-		5 594		6 035		3 962		15 591

ANNEX I

TABLE 9. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

3. Central Research Infrastructure (CRI/I)

			PY$_1$		PY$_2$		PY$_3$		PY$_4$		PY$_5$		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
31. Infrastructure														
311. Laboratory (2 000 m2)	m2	0.75	-	-	-	-	(500)	375	(1000)	750	(500)	375	(2000)	1 500
312. Green house & shelter (500 m2)	m2	2.	-	-	-	-	(250)	500	(250)	500	-	-	(500)	1 000
313. Library (200 m2)	m2	0.75	-	-	-	-	(100)	75	(100)	75	-	-	(200)	150
314. Workshop unit (200 m2)	m2	0.75	-	-	-	-	(100)	75	(100)	75	-	-	(200)	150
315. Guest house & cafeteria (200 m2)	m2	0.75	-	-	-	-	(100)	75	(100)	75	-	-	(200)	150
316. Office (200 m2)	m2	0.75	-	-	-	-	(200)	150	-	-	-	-	(200)	150
S/total Infrastructure			-	-	-	-		1 250		1 475		375		3 100

ANNEX I
TABLE 10. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)
3. Central Research Infrastructure (CRI/2)

	U	UC	PY$_1$		PY$_2$		PY$_3$		PY$_4$		PY$_5$		TOTAL	
			Q		Q		Q		Q		Q		Q	
32. Equipment														
321. Laboratory	set	300	-	-	-	-	(0.25)	75	(0.50)	150	(0.25)	75	(1)	300
322. Greenhouse & Shelter	set	300	-	-	-	-	(0.50)	150	(0.50)	150	-	-	(1)	300
323. Library	set	100	-	-	-	-	(0.50)	50	(0.50)	50	-	-	(1)	100
324. Workshop unit	set	100	-	-	-	-	(0.50)	50	(0.50)	50	-	-	(1)	100
325. Guest house & cafeteria	set	100	-	-	-	-	(0.50)	50	(0.50)	50	-	-	(1)	100
326. Office	set	100	-	-	-	-	(0.50)	50	(0.50)	50	-	-	(1)	100
327. Vehicles														
· Tractor	unit	20	-	-	-	-	(3)	60	-	-	-	-	(3)	60
· FWD	unit	20	-	-	-	-	(2)	40	-	-	-	-	(2)	40
· Break	unit	15	-	-	-	-	(2)	30	-	-	-	-	(2)	30
· Sedan	unit	10	-	-	-	-	(12)	120	-	-	-	-	(12)	120
· Pick up	unit	10	-	-	-	-	(9)	90	-	-	-	-	(9)	90
· Mini bus	unit	60	-	-	-	-	(1)	60	-	-	-	-	(1)	60
· Motorcycle	unit	1	-	-	-	-	(12)	12	-	-	(12)	12	(24)	24
S/total Equipment				-		-		837		500		87		1 424

ANNEX I

TABLE 11. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)

3. Central Research Infrastructure (CRI/3)

	U	UC	PY$_1$		PY$_2$		PY$_3$		PY$_4$		PY$_5$		TOTAL	
			Q		Q		Q		Q		Q		Q	
33. Personnel														
331. Direction														
· Chief (nat.)	m/y	10	-	-	-	-	(1)	10	(1)	10	(1)	10	(3)	30
· Deputy (nat.)	m/y	7	-	-	-	-	(1)	7	(1)	7	(1)	7	(3)	21
· AFD (nat.)	m/y	7	-	-	-	-	(1)	7	(1)	7	(1)	7	(3)	21
· Assistant (exp.)	m/y	75	-	-	-	-	(1)	75	(1)	75	(1)	75	(3)	225
332. Researcher														
· National	m/y	5	-	-	-	-	(6)	30	(6)	60	(6)	30	(18)	90
· Expatriate	m/y	75	-	-	-	-	(6)	450	(6)	450	(6)	450	(18)	1 350
333. Other staff														
· Technician (nat.)	m/y	3	-	-	-	-	(12)	36	(12)	36	(12)	36	(36)	108
· Consultant & Auditor	m/m	10	-	-	-	-	(10)	100	(10)	100	(10)	100	(30)	300
· Support staff Seasonal labor	m/y	1.25	-	-	-	-	(120)	150	(120)	150	(120)	150	(360)	450
S/total Personnel				-		-		865		865		865		2 595

ANNEX I
TABLE 12. BIOTECHNOLOGIES IN FORESTRY AND AGROFORESTRY ('000 US $)
3. Central Research Infrastructure (CRI/4)

			PY_1		PY_2		PY_3		PY_4		PY_5		TOTAL	
	U	UC	Q		Q		Q		Q		Q		Q	
34. Operation														
341. Maintenance of infrastructure	1	1	-	-	-	-	-	-	1	1	4	4	5	5
342. Vehicles														
· Tractor	4 200 km/y	9	-	-	-	-	(3)	27	(3)	27	(3)	27	(9)	81
· FWD	36 000 km/y	9	-	-	-	-	(2)	18	(2)	18	(2)	18	(6)	54
· Break	36 000 km/y	9	-	-	-	-	(2)	18	(2)	18	(2)	18	(6)	54
· Sedan	36 000 km/y	7	-	-	-	-	(12)	84	(12)	84	(12)	84	(36)	252
· Pick up	36 000 km/y	5	-	-	-	-	(9)	45	(9)	45	(9)	45	(27)	135
· Mini bus	36 000 km/y	20	-	-	-	-	(1)	20	(1)	20	(1)	20	(3)	60
· Motorcycle	1	0.5	-	-	-	-	(12)	6	(12)	6	(12)	6	(36)	18
343. Infrastructure														
· Green house & shelter														
· Library														
· Workshop unit	1	750	-	-	-	-	(1)	750	(1)	750	(1)	750	(3)	2 250
· Guest house & cafeteria														
· Office														
· Training & visit														
S/total Operation				-		-		968		969		972		2 909

RESEARCH ON, AND DEVELOPMENT OF NURSERY PRACTICES AND TECHNIQUES FOR THE ESTABLISHMENT AND MANAGEMENT OF FUELWOOD PLANTATIONS, INCLUDING WATER HARVESTING AND DISTRIBUTION

Forest Resources Division
Forestry Department
FAO, Rome, Italy
Based on the work of
C. Cossalter and O. Souvannavong
Centre Technique Forestier Tropical, France

CONTENTS

		Page
0.	ABSTRACT	189
I.	SCOPE OF THE DOCUMENT	191
II.	THE PROBLEM	191
21.	Fuelwood shortage: One cause of the degradation of the environment in dry tropical Africa	191
22.	Plantations as a solution to the fuelwood problem	193
23.	Constraints to tree planting	194
231.	Large-scale rainfed plantations	195
232.	Rural plantations	197
233.	Irrigated plantations	197
24.	Directions taken in plantation forestry	198
241.	Large-scale rainfed plantations	198
242.	Rural plantations	198
243.	Irrigated plantations	199
25.	Conditions for improving plantation forestry in dry tropical Africa	199
III.	IDENTIFICATION OF NEEDS	200
31.	Research needs	200
311.	Choice of plantation site	200
312.	Choice of species	202
313.	Nursery	204
314.	Rainfed plantations	209
315.	Irrigated planting	218
32.	Knowledge dissemination and training needs	221
321.	Knowledge dissemination	221
322.	Training	225

IV. PRELIMINARY PROJECTS PROPOSED 229

Project No. 1: Continuing Training for Forestry Staff 229

Project No. 2: Preparation of Analytical Bibliographies Specific to Dry Tropical Regions in the Field of Nurseries, Plantation Establishment and Management 233

Project No. 3: Directory of Forestry Research in Dry Tropical Africa 235

Project No. 4: Directory of Forestry Development in Dry Tropical Africa 237

Project No. 5: Nurseries: Evaluation of Techniques Used, Dissemination of Knowledge, Planning of Further Research 239

Project No. 6: Plantations: Evaluation of Techniques Used, Dissemination of Knowledge, Planning of Further Research 244

Project No. 7: Development of a Site Description Method 250

Project No. 8: Hardening, under Sahelian Conditions, of Gum Acacias Propagated by Tissue Culture 253

DOCUMENTATION AND RESEARCH CONSULTED 255

APPENDIX I Extract from: "Land evaluation for forestry - FAO Forestry Paper 48". 258

APPENDIX II Future of Plantations of Gum Acacias in the Sahel 261

ABBREVIATIONS USED

BAD	African Development Bank
CILSS	Permanent Inter-State Committee for Fight against Drought in the Sahel
CNRF	National Forest Research Centre (Senegal)
CTFT	Centre Technique Forestier Tropical
FAO	Food and Agriculture Organization of the United Nations
FED	European Development Fund
INRAN	National Agricultural Research Institute (Niger)
IRBET	Institute for Research in Tropical Biology and Ecology (Burkina Faso)
IUFRO	International Union of Forestry Research Organizations
OAPF	Opération Aménagement et Production Forestières (Mali)

CURRENCY

1 CFA franc = 0.02 French francs
0.0025 US dollars

1 US dollar = 400 CFA F.
8 French francs

1 French franc = 50 CFA F.
0.125 US dollars

ABSTRACT

Overuse of natural vegetation to supply fuelwood is one of the main causes of environmental degradation in dry tropical Africa. On the basis of forecasts of future populations and energy policies, the dependency on fuelwood is expected to remain high for a long time. Attempts to combat this phenomenon, and desertification in general, have not so far been spectacularly successful. Planting trees, which is one solution suggested to solve the problem, has limitations that are not all of a technical kind. Research must be undertaken to add to our already considerable knowledge. Application of basic data remains imperfect in many cases. A strong effort in scientific and technical development must be undertaken as well as in training of personnel, but technology alone cannot solve all problems. No attempt at rural development can succeed without the support of the people. From now on we must think in terms of integrated overall management, and deal with forestry concerns within the general framework of rural problems, working closely with the local people and attempting to answer their needs. To set this new approach on a solid base, new directions may be required in the area of administrative law. Also, forestry activity in the Sahelian zone will remain ineffective for as long as there is no pastoral code.

The table that follows summarizes the proposed projects.

	Project Title	Duration	Budget
No. 1	Continuing training for forestry staff		
	• Evaluation and preparation of project document	3 months (expert)	36 250
	• Establishment and operation of training units	5 years	4 020 000
		Total	4 056 250
No. 2	Preparation of analytical bibliographies specific to dry tropical regions in the field of nurseries, plantation establishment and management		
	• 1st edition	13 months (expert)	45 000
	• A revised edition every 3 years	3.5 months (expert)	15 000
No. 3	Directory of forestry research in dry tropical Africa		
	• 1st edition	1.5 months (expert)	20 000
	• A revised edition every 3 years	1.25 months (expert)	17 500
No. 4	Directory of forestry development in dry tropical Africa		
	• 1st edition	3 months (expert)	33 000
	• A revised edition every 3 years	1.75 months (expert)	22 000

	Project Title	Duration	Budget
No. 5	Nurseries: evaluation of techniques used, dissemination of knowledge, planning of further research		
	• Evaluation of existing techniques and practices	4.5 months (expert)	87 500
	• Distribution of technical data sheets and extension manuals	0.25 month (expert)	45 750
	• Preparation of project documents	1.25 months (expert)	14 000
	• Performance of research contracts	3-5 years	177 500
		Total	324 750
No. 6	Plantations: evaluation of techniques used, dissemination of knowledge, planning of further research		
	• Evaluation of existing techniques and practices	10 months (expert)	183 000
	• Distribution of technical data sheets and extension manuals	11.5 months (expert)	98 000
	• Preparation of project documents	4 months (expert)	27 000
	• Performance of research contracts	3-10 years	287 500
		Total	595 500
No. 7	Development of a site description method		
	• Theoretical approach and preliminary data collection	15 months (expert)	225 000
	• Testing of the method through a network of observation areas - case studies	10 months (expert)	370 000
	• Appraisal and final adjustment of the method	3 months (expert)	35 000
		Total	630 000
No. 8	Hardening under Sahelian conditions of gum acacias propagated by tissue culture	3 years	79 900

I. SCOPE OF THE DOCUMENT

During the 17th International Conference of IUFRO (Kyoto, Japan 1981), a Special Programme was designed for developing countries. One of the aims of this Programme is to draw up priorities for forestry research at regional levels.

A Workshop was planned for the Sahelian and North-Sudanese zones of Africa in January 1986 in Nairobi.

The present document, prepared at the request of IUFRO to analyze the current situation and trends, is entitled:

> 'Research on and development of nursery techniques and techniques for the establishment and management of fuelwood plantations, including water harvesting and distribution.'

Complementary fields of research will also be treated within the framework of the Workshop.

The present document is focussed on the following West African countries: Burkina Faso, Cameroon, Gambia, Mali, Mauritania, Niger, Nigeria, Senegal, Chad and the Cape Verde Islands.

The necessary data were collected during several field trips to:

Cape Verde	from 31 July to 2 August 1985 (C. Cossalter)
Mali	from 23 July to 27 July 1985 (C. Cossalter)
Mauritania	from 5 August to 13 August 1985 (C. Cossalter)
Niger	from 7 July to 11 July 1985 (O. Souvannavong)
Nigeria	from 7 October to 11 October 1985 (C. Cossalter)
Senegal	from 27 June to 6 July 1985 (O. Souvannavong) from 28 July to 30 July 1985 (O. Souvannavong) and from 3 August to 4 August 1985 (C. Cossalter)

As far as the countries which have not been visited are concerned, the consultants worked from available documents (CTFT, FAO).

II. THE PROBLEM

21. Fuelwood shortage: One cause of the degradation of the environment in dry tropical Africa

The drought which has affected dry tropical Africa for approximately fifteen years has been an eye-opener: it has aggravated a process of degradation, started earlier and caused mainly by ever-increasing human and livestock pressures.

Trees and woody vegetation play an important role in dry Africa in the daily lives of the people. The need for new arable lands, wood (timber, but above all, fuelwood), fodder and new rangelands, has brought about, more than any other type of use of the environment, a worsening of the process of deterioration. A close correlation can be found between this deterioration of the environment on the one hand, and on the other, the population explosion of the last decades and low technological standards of agriculture and energy. Priorities differ according to the ecological zones concerned in the present study: Sahelia-Saharan (rainfall of 150 to 300 mm); Sahelian-Sudanese (rainfall of 300 to 600 mm); Sudanese-Sahelian (rainfall of 600 to 900 mm).

The need for new arable lands is particularly felt in the densely populated areas where population growth is greatest, i.e. essentially the Sahelian-Sudanese zone. The difficulties faced by the intensification of agriculture in these areas implies an increase of the cultivated areas to obtain a yield increase, which leads to a decrease of the tree cover.

The need for more browse and new rangelands to meet the increase in livestock numbers is particularly great in the Sahelian-Saharan zone where cattle raising is the most important, if not the exclusive activity. It is a nomadic or semi-nomadic type of cattle raising and is uncontrolled. The drought of the last decades, combined with the over-exploitation of pastures, has brought about irreversible damage to the woody vegetation in the grazing areas. As a response to the disappearance of the grass cover, the graziers have resorted to browse, resulting in excessive branch stripping, then pollarding or clear-cutting. Large herds have moved from the north into the Sahelian-Sudanese zone, into traditionally sedentary or semi-nomadic grazing areas, disrupting the already precarious ecological balance and causing serious damage especially to the crop and fallow land.

Wood currently amounts to 80 to 90% of the energy supplies of the region. The use of other sources of energy on a large scale, for example oil, is out of the question for the time being as costs are too heavy for the local economies to bear. The need for fuelwood (firewood and charcoal) thus exists everywhere and increases continually with the population growth. The supply of fuelwood causes over-exploitation of the stands on a local level, particularly in the more densely populated rural areas and in the outskirts of large urban centres. The urban supply areas vary in size according to the size of the population and the existing resources of wood. Thus, if we take for example Nouakchott (Mauritania), located in the Sahelian-Saharan zone, the corresponding supply area is in the Senegal River region, 200 miles away from the town. Dakar (Senegal), the largest city of dry western Africa, receives its supply of charcoal from areas located up to 400, or even 500 miles away from the town. In the case of some other urban centres in the Sahelian-Sudanese zone (St. Louis, Niamey, Maradi, Zinder) provision of fuelwood causes intensive exploitation of all potential sources of wood within a range of 100 to 200 miles from the centres.

A survey undertaken by FAO in the seven member states of the CILSS (Keita 1982) shows a gap between the demand in wood and the allowable cut1/ "of the accessible woody vegetation over a large part of this area (more than

---

1/ Technical term referring to the volume that can be exploited without endangering the sustainability of the resource.

80% of its surface and 61% of its population)." The deficit is covered at the cost of over-exploitation of the woody resources. Such a constantly increasing tapping of the potential yield causes grave, continuing worsening of the fuelwood deficit.

Given the forecasts both on the population and energy policy levels, the dependency on wood as a source of energy can be expected to remain very important for the foreseeable future. Thus, solving the fuelwood supply problem would lead to major reductions in environmental degradation in dry tropical Africa.

22. Plantations as a solution to the fuelwood supply problem

It has been thought for some time that a great proportion of the demand for firewood could be met by reforestation. For the last fifteen years most of the countries of the Sahelian-North-Sudanese zone have therefore set up plantation programmes that fall under three main categories:

Large-scale rainfed plantations, which are heavily mechanized. Such plantations are generally set up within the framework of national forestry department projects.

Rural plantations, a term that refers to (1) reforestation on individual or community lands mainly to supply posts, poles and other building materials; (2) plantations that partition the land in order to intensify cultivation or protect crops (windbreaks, shelterbelts, live fences); (3) the combination of trees and crops in order to optimize yield per unit area and to maintain the fertility of the soil; and (4) amenity plantations (row planting; shade around schools, houses, market places).

Irrigated plantations, which have been established most often as part of hydro-agricultural projects.

Although these activities have been provided with relatively significant resources, it is clear that almost all fuelwood consumed still comes from natural vegetation and woody regrowth on agricultural fallow land. Several reasons of this can be seen, some of the most significant being:

- the low commercial value of fuelwood, which does not make production on plantations economically feasible;
- the large potential still represented by natural vegetation, even though it is continually declining; and
- the relative lack of success of plantations.

The constraints on plantations of all types will be discussed later, as will their present situation and their future in the face of the fuel problem.

Management of natural vegetation is one of the most promising solutions, in the light of present circumstances. Based on research into natural regeneration (in Burkina Faso, Cameroon, Mali, Niger, Nigeria, Chad), which in some cases has been carried out over long periods, some applications have already started and others are still under development. However, all natural vegetation areas cannot be managed. Fundamental obstacles are their scattered locations and consequently their inaccessibility and distance from the centres of consumption, and in some cases their precarious equilibrium or even advanced deterioration.

Maintenance of trees within traditional agrarian systems can also contribute toward satisfying requirements for fuelwood. Activities that encourage rural people to protect adult trees and young regrowth in a park type of vegetation, for example, have been shown to be very effective (DOSSO project on *Acacia albida* in Niger).

Finally, concerning the various types of forestry activities, that is, plantations of all types, management of natural regeneration, and maintenance of trees within traditional agrarian systems, the following may be said:

- Through rational management they could satisfy requirements for fuelwood in the rural environment (including the requirements of medium-sized settlements), in Sudanese-Sahelian areas as well as Sahelian.
- They cannot by themselves solve the problem of fuelwood supply for large settlements.

To solve the overall problem of satisfying requirements for fuelwood, it is necessary to turn to other solutions:

- Energy saving, particularly by improvement in the energy yield of stoves (improved stoves).
- Importation of fuelwood (charcoal, and perhaps in future dry wood).
- Alternative sources of energy: coal in Niger, peat and fossil wood in Senegal, kerosene and butane gas in Nigeria.
- New sources of energy: solar energy and biogas.

The importation of wood from more humid areas and the replacement of wood by other energy sources (kerosene, gas) are practices that are relatively well developed and expanding in northern Nigeria (that country is an oil producer and extends into more favourable ecological zones). For other countries these solutions seem rather difficult to apply at present: production of fuelwood from tropical forests poses numerous problems and has been shown to be costly. In any case, countries in humid zones which on a regional basis might be concerned with this type of production have their own energy problems (the Ivory Coast, for example). Finally, the insufficient financial resources of the countries of dry tropical Africa and the impact of the economic crisis, which is more marked in these countries than elsewhere, sharply limit for the present their capabilities for developing alternative energy sources.

23. Constraints to tree plantations

The objective of the present study is to propose measures for improving the technology for establishment of plantations. To give a clearer idea of the part played by technological problems in the difficulties encountered, the major constraints on various types of plantation are described below.

231. Large-scale rainfed plantations

Difficult ecological conditions: the factor that limits vegetation in the dry zone is the quantity of moisture available to plants. This is a function of both soil and climatic factors.

Plantation soils have not in general been assessed in a satisfactory way. There are very few cases where soil surveys were carried out beforehand at the desired level of detail. The heterogeneity of the soils has therefore been greatly underrated, and too little attention has been given to their physical characteristics (depth and structure favorable to rooting and moisture retention). The combination of poor choice of soils and the rainfall deficit[1] has resulted in very heterogeneous plantations with significant dieback. In the case of E. camaldulensis, for example, experience shows that its use in large-scale plantings should be restricted to zones with an annual rainfall of more than 700-800 mm. This limitation could be reduced locally in areas where the atmospheric humidity (coastal zone of Senegal, Cape Verde Islands), or exceptional soil conditions make up for the rainfall factor.

Poor technology transfer between research and development, and loss of technical knowledge: In the field of reforestation a significant amount of practical, concrete information has been gathered. Optimal use of this body of knowledge, even if not perfect, would allow many problems to be solved. However, the oppposite is often the case: poor development of research results, poor application of techniques with unfortunate effects on productivity and revenues, and so on.... This situation exists at a time when the current drought conditions demand special care in all trials. Ultimately this process can have serious impact on the conduct and direction taken by a project; for example, low-performance stock may be used instead of a species that holds promise for reforestation, because of such things as lack of mastery of techniques of nursery production; or serious disruptions in organization of labor and in conduct of the planting program may occur because of repeated setbacks in the nursery. The cause of this erosion of knowledge must be sought in the structure and training, especially the lack of continuing training, of managers and field officers, and in deficienties in the dissemination of information.

Added to these difficulties, which could be resolved in future by improving the level of knowledge and its dissemination and by more careful selection of sites and planting stock, are constraints arising from the nature of the projects themselves, such as their size and structure. Such constraints involve:

---

[1] Note that the rainfall deficit from 1968 to 1984 reached a level of 200 mm/year. The deficit was made worse by an increase in the irregularity of rainfall, in terms of both seasonal and geographical distribution.

Organizational problems: Concentration of the task of planting within a short period results in severe constraints on the organization of labor: for example, the need for workers at a time when the labor force is busy with agricultural chores. Unfortunately, mechanization can only partially solve these problems. Other problems arise directly from existing organizational structures (poor management of personnel and equipment, bad planning, etc.) or from local conditions (difficulties with the supply of fuel, spare parts, etc.) In general, every organizational problem that results in a reduction of efficiency and/or productivity adds to the cost of production.

Problems with integration of the rural population: Since the rural population does not have any rights, in the short or long term, over plantations set up and managed by state projects or offices, it does not feel any interest in them, nor does it acknowledge the importance of protecting and respecting them. This leads to illegal cutting and damage from fire, grazing, etc. In addition, in some densely populated areas, large-scale plantations may compete with agriculture for available land and this inevitably leads to hostility of the population.

Need for protection against animals: The current practice of grazing, based on freely moving animals, is one of the major constraints. In the Sahelian area where these problems are sharpest, it would be foolish to hope to establish successful large-scale plantations without a protective fence, even in the case where the local population is directly involved in the project. Following the shift of grazing activities southwards and the appearance of large herds on the outskirts of urban centres, protection against cattle is becoming increasingly important in the Sudanese-Sahelian zone (as in the case of the OAPF plantations, established successfully in the classified forests on the outskirts of Bamako).

The problem of integration of products into existing distribution channels: The recurring costs of large-scale plantation projects have often been too high for the national forestry departments responsible for their continuation, and this accounts for the abandonment of some plantations when the external financial support comes to an end.

Most of the above-mentioned factors meet with two major, closely related constraints:
Low productivity, often little better than that of natural vegetation.

High cost price of products: Experience from many projects shows that the cost price of fuelwood produced on large-scale plantations (whose cost per hectare is about 300 000-350 000 CFA) is approximately double the price of conventionally marketed wood coming from agricultural fallow land and natural vegetation.

This reality differs from predictions made when the first projects were started. It must be noted that those predictions were highly optimistic, particularly as regards productivity, which was obtained from a special set of conditions[1] not amenable to extrapolation to a large scale.

232. Rural plantations

Motivation and available land: Motivation of the rural population to participate in, or initiate, reforestation projects presupposes real needs for wood. When sufficient arable lands are available (a prerequisite for reforestation projects), motivation is generally low. When motivation exists, it is usually because wood resources are low, so available land is scarce or barren. In addition, it is often only after the plantations have been established that the rural population grows aware of the fact that the reforested lands are dedicated to another use and lost for crop growing. Wrongly assessing the available lands of a rural community may lead to the creation of plantations that will be subject to constant damage by the population.

Ownership of the products: One reason for the failure of community reforestation projects is lingering doubt about the future ownership of the products. This is why the current trend is towards family rather than communal plantings.

Maintenance costs and protection: When a plantation is established the rural population is not always aware of the heavy maintenance costs and the necessity to protect the plantations permanently against fires and grazing.

Lack of technical expertise: This problem is felt more or less acutely in all stages of the life of a plantation: poor seedlings, inappropriate planting techniques, poor and badly timed silvicultural practices, insufficient protection against cattle, wasteful harvesting methods, etc. All these factors, which contribute to low yields, often lead to dissatisfaction of the rural population.

233. Irrigated plantations

Experience with irrigated plantations is of recent origin, but a few pilot projects (in Mali, Niger, Senegal) have given us some indications of their limitations:

- High costs of start-up and management: around 1 100 000 CFA/ha at 2.5 years, at the pilot stage, with use of gravity furrow-irrigation.
- Difficulty in transferring the intensive system developed at research sites to irrigated farm borders, because of poor control of water and lack of monitoring and maintenance, both of plantations and installations.

These obstacles restrict the proliferation of this type of plantation, even though a sizeable region of irrigable land, still largely unused, lies in the Sahelian zone along the Senegal and Niger rivers.

---

[1] Results from small, well tended research plots and good soils.

24. Directions taken in plantation forestry

241. Large-scale rainfed plantations

When the first large-scale tree plantations were started in the late nineteen sixties, the aim was to produce posts and poles, which were difficult to find in natural vegetation. Because the current drought period had not set in at that time, the species selected for planting in most projects was E. camaldulensis. Later, with the increase in rainfall deficits and growing awareness of problems concerning the supply of fuelwood and the phenomenon of desertification, production objectives turned to firewood, but E. camaldulensis continued to be widely used. The setbacks encountered with this species brought discredit to this type of reforestation, which is now used less and less frequently in the dry zone. If a secure future is desired for large-scale plantations, they must take the following steps:

- Use new species that are both drought resistant and productive. There is some promise in certain local improvement and symbiotic associations. At present the true potential and variability of these species are little known.
- Adopt multiple objectives, for example, combine on one site production of fuelwood and forage, or gum and forage, or wood and tannin, etc.
- Establish plantations close to distribution centres and protect them efficiently against cattle.

Concerning start-up costs and production cost prices, there are many reasons for believing that the situation will evolve in future towards wood production from plantations. Current developments with firewood do not clearly reflect the crisis situation that we know exists. At some stage of the shortage when costs of alternative fuels must be taken into account, large-scale plantations perhaps using local species could become economically viable.

242. Rural plantations

Although it is true to state that in some rural areas the gathering of firewood to supply urban centres is accounting for an increasing share of the farmer's income, we are still far away from a situation in which such fuelwood would be provided by plantations.

One of the few examples of profit-oriented fuelwood growing at rural level is located in western Cameroon, in the Bamileke area, a highly populated region (density of more than 100 people/km^2), with a rainfall between 1 500 and 2 000 mm per year. The aim of the plantations is to supply posts to the local markets, and poles for which there exists a high demand (Société Nationale d'Électricité) as well as an organized channel of marketing (private dealers between the plantation-owners and the SONEL). No equivalent example is known from the North-Sudanese zone, nor from the Sahelian zone. Considering the constraints in rural planting, such a trend will only become viable in the dry zone if the plantations will provide specific, profitable products that cannot be obtained from natural stands, such as building posts.

In spite of the scarcity in some areas fuelwood is still often considered a product to be gathered in the wild. Its stumpage value is very low. The motivation for rural populations to plant trees will thus not be the production of wood or firewood but will be prompted by the many other functions of the trees, such as their use as live fences, provision of shade, fruits and fodder. Wood should be considered as a product among others, maybe even as a by-product. The multiple use will determine the choice of species used in rural plantations.

A new trend in family reforestation projects is to assure the production of seedlings from mini-nurseries which are located in the heart of the rural world (Mali, Niger, Senegal). Such a trend should go along with a demythologizing of the concept of the tree nursery, which is still often considered a "specialized workshop" requiring great specialized skills and competence. In Mali, vegetable farmers have already proved capable of producing a large number of tree species, including Eucalyptus. Such a strategy of encouraging private enterprise, and use of plantations to improve rural life, holds much promise. Dissemination of information has an important role in this context.

243. Irrigated plantations

Available data, based on limited experience, show that to be economically viable, irrigated plantations are restricted to intensive production of sought-after products such as posts and poles. The first results obtained on an experimental basis are rather encouraging as regards yield of biomass (35 m^3/ha/year at 2.5 years, with a density of 4444 trees/ha (test in Nianga, Senegal, with gravity furrow-irrigation). It should be possible to make wood production on irrigated plantations profitable within the framework of large hydro-agricultural projects on the Niger and Senegal rivers, if the loss of productivity that occurs between experimental conditions and practical projects could be offset by a reduction of the establishment costs. One of the solutions would be to assure that the plantations benefit from existing local infrastructures and from low-cost irrigation. In such cases, the plantations should be developed either on abandoned agricultural lands, or as row plantings for the protection of crops. Development of irrigated tree plantations thus seems to be closely linked to development of agricultural borderlands, but trees must be accepted in these lands. This shows the real interest in agroforestry research on irrigated borderlands.

25. Conditions for improving plantation forestry in dry tropical Africa

In addition to improving silvicultural techniques, which is dealt with in this report, the development of plantations of woody species requires action in the following fields:

- Development of new production systems:
    - combining trees, crops and range management;
    - closely involving rural populations in the programmes, by providing opportunities for additional income.

- Diversification and improvement of the planting stock, to improve the quality of the products as well as their yield and resistance to drought and disease. Wider use should be made of multipurpose species to achieve this.
- Improvement of site potential:
  - through increased knowledge on site/yield relations;
  - through use of symbiotic associations;
  - through balanced plant protection practices.
- Ensuring marketability of the products:
  - through organizing or improving marketing channels;
  - through upgrading transportation networks.

III. IDENTIFICATION OF NEEDS

For identification of research needs we will now briefly review the techniques presently used in different stages of reforestation, without attempting to cover the subject exhaustively. The needs for training, dissemination of scientific knowledge and extension will be dealt with separately.

31. Research needs

311. Choice of plantation site

In the light of past experiences the choice of a suitable site has been a major factor contributing to the success of plantation schemes. The importance of the soil factor increases with the harshness of the climate. The heterogeneity of the soils in the dry areas has often been underestimated in the past. In Niger, nine provenances of Eucalyptus camaldulensis were tested in a rainfall area of 600 mm (completely randomized block with seven replications and 49 tree plots). In this experiment, yield in the best provenance, at age three, varied from one to eight depending on the soil type (block to block variation); and the provenance means varied from one to four (mean yield calculated over all blocks).

Site selection, as presently practised, generally takes into account only the rooting depth, Based on a number of studies on water balance, it is now known that the major limiting soil factor in dry areas is the availability of water to plants. This is obviously a function of soil depth and moisture content, but also the soil structure has to be such that water is rapidly available to plants; hence the need to consider a number of physical characteristics of the soil: texture, porosity[1], permeability, and density. It will be important to determine precisely which of these parameters could be used as main criteria for describing soils. Appropriate soil evaluation will require that the forester, in the future, familiarize himself with techniques for assessing texture, water balance, etc.

---

[1] Porosity, and particularly microporosity, determines the quantity of capillary water available to the plant through absorption; this is an essential source of water, especially in the dry season. Microporosity is the capillary volume (less than 8 microns) where root bairs and microorganisms grow.

While it is important, the soil is only one of the factors affecting yield. The climatic conditions equally affect tree growth. The production of dry matter by plants is, largely, a function of their transpiration. Research has demonstrated that the production of dry matter is maximized when the water demand, as conditioned by climatic conditions (potential evapotranspiration PET[1/]) is met.

Conversely, the dry matter yield is reduced when the real evapotranspiration (RET[2/]) is less than the PET. The "break" between RET and PET is produced by excessive climatic demand, insufficient availability of soil moisture, or a combination of the two factors. The break occurs through stomatal and cuticular adjustment by plants, which reduces the diffusion of water vapor but at the same time limits exchange of gases, and therefore limits photosynthesis. The "call for evapotranspiration" may be characterized by other indicators, notably the saturation deficit[3/]. This climatic parameter has, according to many experts, a physiological value much closer to reality than PET, and has the advantage of being fairly easy to measure.

In developing this method one must assess the importance and the advantages of all the parameters that might be taken into account. However, some selection must be made, to allow for the practical aspects of application (parameters that are easy to quantify and describe). The method must enable one to judge the suitability of a given site and to compare sites. It must therefore include:

- climatic parameters that affect plant transpiration
- soil parameters (mentioned above) and climate parameters (distribution and intensity of rainfall, total rainfall) that affect the soil moisture reserves
- geographic parameters: latitude, altitude
- physical parameters: relief, slopes
- drainage information
- physiographic description: plateaus, lowlands, valley bottoms, dunes, etc.

[1/] PET is a potential value dependent on several climatic characteristics: net radiation, saturation deficit, temperature and wind. It refers to the quantity of water that would be transpired by the ground cover and evaporated from the soil if there were a limitless quantity of water in the soil.

[2/] RET is the real evapotranspiration, taking into account the adjustment of stomata by plants and self-mulching of soils (a crust is formed by drying out of the upper horizons, which limits evaporation from the lower horizons).

[3/] The saturation deficit, still known as the water deficit or evaporation factor, is the difference between the saturation vapor pressure and the real water vapor pressure.

Annex I, taken from the FAO publication Land Evaluation for Forestry, gives a more comprehensive list of the features that should be considered.

312. Choice of species

In what follows, comments are confined to species currently used in areas of Africa with an average annual rainfall of less than 800 mm, and in semi-arid regions of the Cape Verde Islands with an average annual rainfall of less than 300 mm and altitude less than 250 m. Fruit trees such as citrus, guava, and mango, whose acclimatization to these zones depends largely on the specific environment and the care they receive, are not discussed.

The most common species for rainfed plantations (in alphabetical order):

Local species

Acacia albida: an important species in all countries and extensively used in agroforestry.

A. nilotica ssp. adstringens: traditionally planted for tannin and for shade in certain regions. Quite frequently used by the Forestry Department of northern Nigeria in the production of tannin.

A. tortilis ssp. raddiana: planted in projects particularly in Senegal.

A. senegal: planted in projects for the production of gum arabic, particularly in Mauritania, Niger and Senegal.

Adansonia digitata: its leaves are traditionally used for foodstuffs, particularly in Niger.

Borassus aethiopium: traditionally planted in the fields, in certain regions, for a number of uses.

Euphorbia balsamifera: traditionally planted in all countries of the region for hedges; used to stabilize dunes.

Leptadenia pyrotechnica: used to stabilize dunes, especially in Mauritania.

Parkia biglobosa: planted in agroforestry on the most favourable sites. Ecologically, a borderline species.

Exotic species

Acacia holosericea: use limited to those regions with rainfall greater than:

- 600 mm in continental Africa
- 500 mm in the coastal zone of Senegal where it is frequently used. Used more and more frequently in the Cape Verde Islands.

Azadirachta indica: widely utilized species in most of the countries, especially in Burkina Faso, Mali, Niger, Nigeria and Senegal and particularly successful in row plantations. It is little used in the Cape Verde Islands because it is sensitive to the continual wet trade winds.

Casuarina equisetifolia: extensively used for stabilization of dunes on the coast of Senegal.

Eucalyptus camaldulensis: although it no longer ranks as the first reforestation species in a number of countries because of the decline in large-scale planting, it remains an important and widely utilized species everywhere.

Parkinsonia aculeata: an excellent fodder-producing tree used particularly in the Cape Verde Islands, Mauritania and Senegal.

Prosopis juliflora: the major reforestation species in the Cape Verde Islands and Mauritania; one of the most widely used species in Niger and Senegal.

Most common species for irrigated plantations (in alphabetical order):

Acacia holosericea

Eucalyptus camaldulensis which remains the most productive species for this kind of planting (productivity of 35 m^3/ha/year in Nianga, Senegal, at the age of 2.5 years with a density of 4 444 trees/ha).

Principal rainfed species used on a small or experimental scale (in alphabetical order):

Local species

Acacia laeta, A. nilotica ssp. tomentosa, A. seyal, Anogeissus leiocarpus, Balanites aegyptiaca, Bauhinia rufescens, Detarium senegalensis, Sclerocarya birrea, Tamarindus indica, Ziziphus mauritiana.

Exotic species

Several Australian acacias of which the most interesting is A. trachycarpa, for a long time erroneously called A. aff. linarioides.

Principal irrigated species planted on a small or experimental scale (in alphabetical order):

Acacia nilotica ssp. adstringens, A. nilotica ssp. tomentosa, A. tortilis ssp. raddiana, Azadirachta indica, Dalbergia sissoo,* Eucalyptus brassiana, E. microtheca,* E. resinifera,* E. tereticornis,* Khaya senegalensis, Leucaena leucocephala,* Prosopis juliflora.*

* The most promising species.

The question whether local or exotic species should be used is irrelevant, as it all depends upon the objectives. The choice of a species should be determined by its capacity to adapt to the site conditions and by the objective. There is currently no reliable method for the choice of a species as a function of site conditions. The characteristic conditions of a site are themselves still often ill-defined and incompletely known. The design of a standardized site description method (see 311) will promote progress in this field. The application of such a method to already-planted sites will result in the acquisition of sizeable amount of data as a basis for comparison of site characteristics with good or bad performance (survival rate, productivity, etc.). Analysis, by this method, of a large number of successful and unsuccessful plantings will make it easier to define the behaviour and the demands of reforestation species. These data could then be supplemented and cross-checked by ecophysiological studies (resistance to wilting, amount of transpiration, quality and rate of root development).

313. Nursery

In the following we shall successively discuss:

- Eucalyptus camaldulensis: reputed to be one of the most difficult species to grow in a nursery;
- other exotic species, and particularly the two most important ones: Azadirachta indica and Prosopis juliflora;
- native species and, more particularly, the gum-producing acacias which, because of their economic potential, need more specific research linked to the progress made in other fields.

Eucalyptus camaldulensis

Over the past years, research on Eucalyptus camaldulensis has developed the transplanting technique with polyethylene bags, and, more recently, production in beds. Both techniques, which are extensively described in J.C. Delwaulle's work, entitled "Forestry Planting in Dry Tropical Africa" have been improved upon in recent years, especially in Burkina Faso (by IRBET/CTFT) and in Senegal (by CNSF). However, in the continental region the major constraint in producing plants in plastic bags for transplantation is that seeding must be done before 1 February where the rainfall is 600 mm and before 1 March where the rainfall is 800 mm, so that the transplanting is completed before the hot Harmattan months. This is why nursery growth periods are extended to six or seven months whereas four months would be sufficient to obtain optimum planting size. In northern Cameroon, tests of late seeding (in May) produced resistant plants suitable for planting in July.

Though direct seeding in polyethylene bags is the most widely used technique in development programmes, it calls for further improvements that will be discussed below. Direct seeding in pots is used either directly in the open (Niger), or under shading which is gradually reduced as the seedlings grow. The seeds sown in the centre of the pot, either by hand or by an implement of the one-hole salt-shaker type, are covered with a layer of sand to a depth of 3 to 4 mm. This layer prevents the seeds from drying out (which occurs in the first 2 to 3 mm of the surface layer). Plenty of water is provided either by spraying in the first weeks, or with a watering-can from the very first days, in the morning and evening (Niger). The thinning of the plants is done as soon as there are six leaves. On this occasion extra seedlings are transplanted to empty pots. Such a method, which is used in the nurseries of forestry departments and projects, as well as in village-based nurseries, is simple and has definite advantages:

- seeding is done late (April) than with the pot transplanting technique, so that the nursery raising period can be reduced to 4 months;

- the lengthy and delicate operation of transplanting is eliminated, and so are the risks associated therewith;

- the best plants can be selected during the thinning operation.

Selection could be intensified and would doubtless be an advantage if early selection criteria were available. Research is necessary in this field.

The major inconvenience with seeding in pots is the considerable quantity of seeds required (up to 15 times that required for transplanting into pots) which makes it difficult to use improved seeds since the limiting factor in their use is that only small quantities are available. Given the current trends of raising plants in village nurseries, there is little chance of a return to the traditional technique of transplanting into pots. To improve the direct-seeding technique therefore means to reduce the number of seeds actually sown. The first tests conducted on this point in Niger have had rather encouraging results as far as germination rates are concerned (241 plants/g in seed beds, 246 plants/g in pots). But as regards homogeneity in pots results are still insufficient (63% empty pots with an average of two seeds per pot). Increased post-harvest purification of seeds by removal of impurities and infertile seeds and, perhaps, by coating the seeds for easier handling, would allow a substantial reduction in current consumption levels. It should be noted that direct seeding in pots of Eucalyptus camaldulensis and related species is a technique used on a large scale in certain countries, especially in Brazil.

For irrigated plantations where Eucalyptus camaldulensis is a favourite species, tests are in progress comparing the behaviour of high stumps ("barbatelles") with that of conventional pot-raised plants. Stumps (low and high) are interesting, not only because of low production costs but also because of the possibility of starting, and even transplanting, at the most favourable time, as the regrowth of stumps in plantations is not problematic, regardless of stump diameters. The stumps should be prepared a few days before planting (dressing of the roots and stem) and immersed in water, which generally accelerates regrowth. The economic advantages and technical simplification might also be improved by direct transplanting from the germination beds to the ridges. Some research is required in this field.

Given their high cost of establishment, irrigated plantations are necessarily used for intensive production where it is a priority to develop techniques of propagation by cuttings. Of course such research is meaningful only if it is combined with a stock selection and improvement programme. The CRF in northern Cameroon has obtained early promising results on propagation of E. camaldulensis, Dalbergia sissoo and Khaya senegalensis by the "Gaulinage" method in frames (or in a wet chamber). In Burkina Faso, IRBET/CTFT has been developing this technique since 1984 mainly with E. camaldulensis. In Senegal, CNRF is about to start a research programme on propagation of cuttings in mist.

Other exotic species

In Burkina Faso, Northern Cameroon, Mali, Niger, Nigeria and Senegal Azadirachta indica is a major planting species, while Prosopis juliflora is the most important reforestation species in the Cape Verde Islands and Mauritania, and is one of the most widely used species in Niger and Senegal. In both cases, nursery techniques are quite well understood, as the species concerned are particularly hardy and easy to grow. With Azadirachta indica there is a problem of a rapid loss in germinative capacity, so that for this species it is necessary to use freshly harvested seeds (seed conservation aspects do not fall within the scope of this study). Azadirachta indica can be produced both in pots (direct sowing) and as high stumps (in which case two years' nursery growth must be provided for).

Prosopis juliflora is produced in pots (direct sowing). CNRF (Senegal) has achieved good results when transplanting seeds1/ pregerminated for 18 hours on damp sterile cotton-wool. At first, this species grows very fast; however, it is necessary for it to spend 3 to 4 months in nurseries in order to grow a sufficiently strong stem with a properly lignified base - this will enable it to resist the abrasive and drying effects of the sand-laden wind (Mauritania) as well as the swarms of locusts (Cape Verde Islands). Plants grown in polyethylene bags - with diameters of 7.5 to 10 cm and depths of 20 to 25 cm, varying from one country to another - need one or several toppings in the course of their nursery growth, because they should be only 55 cm high at the time of planting. Then the base diameter of the stem is about 0.5 to 0.8 cm. With present day techniques there seems to be no major root distortion problem; indeed the taproot reaches the bottom of the pot at about 3 months, and the side roots do not grow much. A possible improvement for this technique would be to speed up the lignification and the diameter growth of the stem, without necessarily increasing the diameter of the bags (spacing out the rows of plants in nurseries, applying fertilizers ?).

High stumps have been successfully produced for Prosopis juliflora in Tunisia; they have been tested on a small scale in the Cape Verde Islands and should be adapted to Sahel conditions. Such tests should also be extended to Parkinsonia aculeata and to Acacia holosericea. Improvements in the propagation by cuttings of Prosopis juliflora are also desirable for the purposes of fully using the genetic variability of a species deemed important both in the Cape Verde Islands and in Mauritania. Priority should be given to developing the form of wet chamber propagation by cuttings that is best suited to dry areas.

Indigenous species

In reforestation projects in rural areas there is an increasing demand for indigenous species that are well adapted to local ecological conditions, and known to and used by local populations for a variety of purposes. Problems in nursery raising and transplanting in the field, as well as a poor knowledge of

---

1/ Seeds pretreated by scarification in acid.

the planting performance of these species, are greatly hindering their dissemination. In most Sahelian and Sudanese species the seeds have a hard water-proof tegument causing dormancy phenomena to occur. The seeds often are very slow in germinating, which leads to seeding heterogeneity. In a number of cases emergence is hampered by a germinative capacity that is consistently low (*Anogeissus leiocarpus* less than 10%) or unreliable (*Combretum* ssp., *Cordyla pinnata*), or by the rotting of the seeds (*Vitellaria paradoxa*), or by too hard a seed-shell (*Parinari excelsa* and *P. macrophylla*).

Once the seeds have germinated, nursery growth is still difficult for a number of species, in particular *Detarium microcarpum*, *Isoberlina doka* (yellowing phenomena), *Pterocarpus erinaceus*, *Cordyla pinnata* (slow growth), *Mitragyna inermis* (not readily transplanted). Furthermore, transplanting in the field is problematic for a number of species, including *Acacia albida*, *Vitellaria paradoxa* (taproot fragility), *Afzelia africana* (yellowing phenomena).

The following lists indicate the overall state-of-the-art of results obtained throughout the region; however, the knowledge gained varies considerably from one country to another: indeed, some countries are trying to develop what has become a well-established technique elsewhere. Consequently, the time has come for an assessment of what has been done, and for the dissemination of results in the form of technical data sheets.

Species for which nursery and planting techniques are deemed adequate but with room for improvement:

Acacia albida,* *A. nilotica*, *A. senegal*,* *A. seyal*, *A. tortilis*, *Anogeissus leiocarpus*,* *Adansonia digitata*,* *Balanites aegyptiaca*, *Bauhinia rufescens*, *Ceiba pentandra*, *Combretum aculeatum*, *Diospiros mespiliformis*, *Khaya senegalensis*,* *Leptadenia pyrotechnica*, *Lannea microcarpa*, *Parkia biglobosa*,* *Pterocarpus erinaceus*,* *Sterculia setigera*, *Tamarindus indica*.

The names with asterisks are the subjects of data sheets drawn up by IRBET/CTFT in Burkina Faso.

Major but problematic species:

Afzelia africana, *Cordyla pinnata*, *Detarium microcarpum*, *Isoberlina doka*, *Vitellaria paradoxa*.

Species for which research is in progress:

Acacia gourmaensis, *A. macrostachya*, *A. polyacanta* ssp. *campylacantha*, *A. sieberiana*, *Annona senegalensis*, *Bombax costatum*, *Cassia sieberiana*, *Combretum glutinosum*, *Commiphora africana*, *Ficus gnaphalocarpa*, *Pterocarpus lucens*, *Parinari macrophylla*, *Terminalia glaucescens*, *Terminalia macroptera*, *Sclerocarya birrea*, *Vitex doniana*, *Ximenia americana*.

Species for which CNRF Senegal has developed a preliminary acid scarification treatment (for accelerated germination and greater germination uniformity):

The species with an asterisk can be further improved by pregermination on damp sterile cotton-wool, for 18 to 48 hours, just after the acid scarification treatment.

Acacia albida,* Acacia nilotica var. adstringens,* A. nilotica var. tomentosa,* A. tortilis,* A. senegal,* A. seyal,* A. sieberiana,* Bauhinia rufescens,* Bombax costatum, Cassia sieberiana,* Ceiba pentandra,* Celtis integrifolia, Detarium senegalensis,* Mitragyna inermis, Parinari excelsa, P. macrophylla, Prosopis africana,* Pterocarpus erinaceus,* P. lucens, Sterculia setigera,* Tamarindus indica.*

Given this knowledge, research requirements can be defined as follows:

- to develop simple (hot water) scarification techniques to be used in rural nurseries;
- to continue tests on nursery techniques, in particular for problematic species;
- to study the various degrees of resistance to soil and climate conditions in the major species (in order to refine the direct-sowing reforestation technique);
- to continue tests on preliminary acid scarification, to develop germination-arresting methods, and to conserve pregerminated seedlings.

Research needs are more specific as regards gum trees, in particular A. senegal. The progress achieved with A. senegal in the fields of selection, laboratory cloning, and symbiotic association, is a sign that soon there will be very productive, mass-multiplied clones available for development work (see Annex II).

At the present stage this project still encounters various obstacles, in addition to strictly technical problems:

- the end cost of seedlings: it can be reduced by changes in the growth conditions and media, as well as by the development of large markets;
- the lack of a specialized laboratory in the Sahelian area: it is unthinkable to use a European laboratory as the basis for seedling production at levels required by development. This obstacle might be removed by the biotechnology centre planned in Dakar.

In technical terms, it is still unclear how gum acacias propagated by tissue culture can adapt to non-sterile environments. However, the steps and necessary precautions are known as regards Acacia koa. The essential precaution, which applies to any seedling as it leaves sterile laboratory conditions, is to maintain high humidity during the first days, which is reduced gradually in order to accustom the seedling to local humidity levels. Hardening techniques could be developed with the funding of a specialized nursery in the Sahel, to be supplied initially with laboratory seedlings from Europe, and later from Dakar. This nursery would be managed in the context of one of the current or planned field projects on gum trees (see Annex II).

Research requirements common to all species

Improvement of culture substrates: The better the aeration of the substrate, the bigger and stronger the roots. Often the sand used in nurseries is too fine, and consequently lacking in aeration. The growth of plants, and more importantly of their roots, however adequate, is thus reduced. In order to improve root systems it is recommended to lighten nursery soils with organic matter. The compost heap, the principle of which is well known, is a way of producing the organic matter. The objective for this research effort will thus be to develop a method that can be widely popularized in rural areas. The purchase of any inputs should be avoided as much as possible (local urea and superphosphate sources should be used).

Propagation by cuttings developed as an experimental tool: In addition to their value for the propagation of high performance subjects, cuttings used in propagation provide a very helpful research tool. Thanks to this technique it is possible to monitor genetic variability in order to gain better insight in phenological, physiological and other matters. Clonal stands are ideal experimental material, for instance in developing pruning and coppicing techniques.... Thus various techniques, intensities and times of operation can be compared under strictly identical conditions - absolutely homogeneous study materials, and the possibility for operations to be repeated both in time and in space. With this type of objective, the starting point may be non-selected plants, i.e. cuttings from young stock, either in order to make the method easier or to increase the rate of success (herbaceous shoots taken on young coppiced plants).

It is advisable to develop the method for wet chamber propagation by cuttings, a process which calls for only a small investment, which can be applied anywhere, and which is particularly well suited to regions where water availability and/or pressure can be constraints.

314. Rainfed plantations

314.1 Ground preparation and water management

The soil factor cannot be separated from the climate factor, especially in relation to water. Both factors determine the aptitude of a site for planting. In dry tropical Africa the water reserves contained in the soil are often the major constraint for plantations. Since forestry engineers cannot influence rainfall they must concentrate on ground preparation in order to increase water reserves and reduce water losses.

In the Sahelian and North Sudanese areas, surface compaction or sealing of soils is common, whatever the structure of underlying horizons may be. The surface crust, which is hardened by high temperatures and often reinforced by dark patches of proliferating microscopic algae, is an obstacle to the infiltration of water. Such a crust results either from deterioration of the structure due to compaction (for example in tropical soils containing iron), or from thin deposits of colloidal clay due to the run-off of sheet water. In other soil types, excess clay can lead to soil compaction and impermeability. Such phenomena determine to a great extent the ground preparation and water management techniques described below:

Techniques involving mechanical means: These techniques are called for in industrial-type reforestation operations, when the shape of the terrain allows the use of machines.

Tests in Burkina Faso, northern Cameroon, Niger and Senegal, over a range of fairly different soils, show that the best results are obtained with subsoiling after ploughing at depths of 50 cm or more. Since this technique helps clod formation and reduces topsoil pulverization (the cause of compaction), it is the most conducive to water infiltration. Crossed subsoiling tests for the comparison of single-tined and three-tined tools show that:

- for equal subsoiling intensities, operating along contour lines seems more efficient than operating along the highest gradient;
- subsoiling is more efficient with a three-tined than with a single-tined tool.

With time the beneficial effects of subsoiling on surface water infiltration tend to be diminished. Work required for grass control gradually destroys the clods, which causes the reappearance of an impervious micro-horizon at the surface. In Niger, additional soil preparation is contemplated as soon as subsoiling effects decline (during the third rainy season, sometimes during the second in distinctly unstructured soils). A possible solution is to establish "fishbone" type micro-catchments capturing the rain water around the plant; this would require manual tending in order to avoid breaking the catchments.

Ridging techniques have been tested in these countries, but they were beneficial only on floodable Vertisols in the 500-mm rainfall area of northern Cameroon (plants above water during the rainy season could use accumulated moisture from between the ridges at the start of the dry season). Everywhere else, growth was definitely depressed, more so in drier areas. The ridging and subsoiling combination (not unlike the "steppe" method in northern Africa) may perhaps be of interest in the Sudano-Guinean zone where drought conditions are less marked (rainfall 1000 mm and more).

Ploughing by itself gave positive results only on light soils (especially sand). It is recommended in northern Cameroon with individual planting and agroforestry. On heavier soils it is ineffective as it does not reach down deep enough in the soil and does not help infiltration (rapid recovery of an amorphous structure).

To economize resources projects often use single-tined subsoiling tools, in which case planting is done at the intersections of subsoiling lines.

Techniques involving manual means: These techniques are appropriate for rural planting and must be used where the terrain does not allow the use of machines.

Amongst methods tested in Burkina Faso, Niger and Senegal the large pit method produces the best results, all the more so where the pits are larger - 60 x 60 x 60 cm is an optimum size.

Tests were made to compare this method to the medium size (40 x 40 x 40 cm) pit method, and to methods involving pot-size pits (15 x 15 x 30 cm approximately), and hill planting (mole-hill, knoll and trench), all of which are not appropriate for dry tropical Africa.

Manual ground preparation is advocated for the construction of several surface-water recovery arrangements, with a view to economizing water and/or to controlling erosion.

The fishbone arrangement is a half-moon catchment (about 1 m diameter) established around each plant. A ridge of earth 10 cm high, reinforced with stones if necessary, is constructed on the downstream side of the plant. Two small channels connect each catchment to the "upstream" catchments. This method was successfully tried out on flat or very gently sloping land in Niger, where it made it possible to maintain sizeable soil water differentials between the plant surroundings and outside the fishbone catchments, for up to 6 months after the rainy periods.

The water economics of the Cape Verde Islands - a land of mountains - differ considerably from those of the generally flat Sahelian and North Sudanese areas.

Compaction does not occur in most Cape Verde Island soils. Slopes are the major runoff factor. Here devices are set up both to supply plants with additional water resources and to protect soils from runoff water effects.

Along the same lines as the fishbone arrangement, the "individual crescent" device aims at capturing the water of a runoff area covering some 25 m^2, in order to channel it to the accumulation/infiltration site around the plant.

Bench terraces arranged along contour lines are also used. The steeper the gradient, the narrower the spacing of the terraces - and the smaller the runoff area.

Individual crescent-and-terrace arrangements applied in all reforestation operations in the Cape Verde Islands are fully satisfactory. Other water -and soil - conserving methods are described in the publication "Soil Conservation South of the Sahara".

Today, fairly diversified soil preparation and water management techniques are available, but there is no accurate criterion for a reasonably reliable prognosis of what method should be applied to any given site. This is due to the fact that not enough attention has been given to the relationship between techniques and implementation site parameters. Furthermore, as there is no standardized method for site description, there is little scope for site-to-site comparison, which makes extrapolation a risky exercise. Under these circumstances it seems preferable to undertake a comprehensive assessment of existing methods on the basis of accurate, appropriate and standardized site characterization criteria, rather than new and strictly technical research.

Artificial water retainers and antitranspirants: Artificial water retainers of the polyacrylamide type truly behave as chemical sponges, but their life as compared to their cost does not justify using them in low-value production.

Film-type antitranspirants are oils or polymers, which are sprayed onto the plants in order to reduce both circular and stomatal transpiration. They act in a solely mechanical fashion (closing the stomatal ostioles) and they are efficient for only about ten days. Treatments can be repeated regularly without any side-effect on the plants. Although they are easy to implement and allow a free choice of time of treatment, these substances do not offer a great potential in forestry; indeed, as they are widely used in citrus, or fruit, tree cultivation for instance, it may be implied ipso facto that they involve limitations or constraints which the existing literature hardly describes.

Stomatal antitranspirants are, in general terms, the substances that can induce stomatal closure, thus reducing or eliminating stomatal transpiration which amounts to 90% of total transpiration. Actually, they often happen to be agrochemicals (straw shorteners, fungicides) with mercury or chlorine components; their anti-transpiration function was discovered from relatively large-dose applications. Tests are being conducted on an antitranspirant based on usnic acid[1] - in Mali[2] and Niger[3]. It should be noted that it is paradoxical to use stomatal antitranspirants inasmuch as they act as stomatal aperture reducers when water is available (when it becomes unavailable, the plant itself adjusts its transpiration). Consequently, such products can only be applied when the nature and preparation of the soil, or the addition of a water-retaining substance, allow the soil to retain the water saved from transpiration, or when that water is absorbed by the next plant (as in high-density plantations and in tree-crop combinations). Otherwise it is useless to save the water for it is lost in evaporation.

Very recent (1984 and 1985 planting seasons) tests in Mali and Niger revealed no beneficial effects of antitranspirants. In any case these products are costly to produce (at the present stage of experimental-scale manufacturing, they cost 5 to 7 times more than the value of the plants).

There is apparently very little scope for antitranspirants to be used in reforestation. It will be interesting to obtain the results of current experiments, but we do not, at the present stage, recommend any new research to be started in this field.

---

[1] Developed by the chemistry laboratory of the Paris Natural History Museum.
[2] Tests conducted by INRZFN in cooperation with the Museum.
[3] Tests conducted by INRAN in cooperation with the Museum.

314.2 Spacing in planting operations

Where there are no environmental or species-related constraints the spacing in between planted trees is determined by technical criteria - desirable product characteristics, felling cycle.... In the dry tropical area, ground reserves of usable water, and water requirements of the plants, are usually predominant factors. For instance, in an excellent soil with optimum water storage and infiltrability characteristics, it is acceptable to have close-spaced (4 x 4 m with 600 mm rainfall) plants in the case of Eucalyptus camaldulensis. Otherwise, wider spacing should be applied, up to 5 x 5, for the same species and with the same rainfall level - but then very low productivity is achieved per hectare.

The spacing is generally determined by the type of soil chosen.

It will be possible to obtain valuable data through an assessment of planted sites based on a standardized characterization method such as is advocated above in paras 311 and 312.

Studies on the root systems of adult trees have been in progress since 1983 in Niger, in order better to understand aspects of competition in plantations. Interesting data have already been collected for Acacia laeta, A. senegal, A. seyal, Balanites aegyptiaca, E. camaldulensis and Prosopis africana. This type of research should be continued in combination with studies on water resources and on soil characterization.

314.3 Fertilization

Research on fertilization concerns the climate-water-soil-species series, which means that it should be conducted chiefly in the field in view of the sheer variety of combinations of the four factors. In Niger, for instance, fertilizer inputs led to no significant improvement in Eucalyptus growth. In several cases they rather had a depressing effect. Fertilizers increase the saline solution in the soil, particularly during the dry season, which probably makes it more difficult for the water to be osmotically absorbed. Thus the trees potentially receive less water, and grow apparently less than unfertilized plants. In Niger, research results consequently argue against mineral fertilization in rainfed planting operations.

Rather than any new research, we advocate an assessment of a number of characteristic plantations, for the purposes of correlating fertilization results and site characteristics.

314.4 Planting time

In "Forestry Planting in Dry Tropical Africa", J.C. Delwaulle describes a statistical calculation method for optimum planting timing. The method is a response to the following question: "how soon after rain is there a 75% chance of another rain in the next 3 days?". In the case of Niamey the method indicates that "it is possible to plant after the first rain following 11 July", a statement which coincides with the results of tests on planting times. The method is still valid with different basic data: for instance, an 80% chance of another rain within 5 days. However, it is necessary to know how often it has rained on a daily basis over quite a number of years in order to apply it. Many tests and observations by other forestry specialists in dry areas have resulted in another specific method for the same problem. It might be interesting to record existing approaches, and to compare them with due regard for rainfall differentials and to assess their reliability.

It would be worth while studying the practical and economic prospects of pre-season planting with some additional watering, in order to analyze costs, possible growth and production gains, and possible tending savings.

314.5 Planting mode

The best method in low rainfall situations, which is also the most widespread, is to grow plants in polyethylene bags. However, other techniques are acceptable, for instance high stumps, high stems, direct sowing, direct propagation by cuttings.

Polyethylene bags: Bag planting is a very well-known planting mode; here it will suffice to mention an approach that can make young plants more drought-resistant.

In Mauritania, the so called "deep planting" method, which consists in burying the collar under some 30 to 40 cm of soil (bagged plant placed at the bottom of a hole some 50 to 60 cm deep), produces good results on dunes, especially with Prosopis juliflora. This method allows the roots to be in contact as soon as the trees are planted with a zone of normally rather high residual humidity. It also gives some protection against baring effects around the young plant. In Prosopis juliflora rootlets appear after a few weeks on the earthed-up part of the stem that had been trimmed prior to planting. This method has been tested in Senegal under the PRECOBA project in sandy clay soils (deck dior) of the ground-nut growth area; it is reported to produce good results, especially with E. camaldulensis (better growth, better termite resistance, than in ordinary planting). In sandy soils (deck) "deep planting" is reported to have enabled species such as A. nilotica var. adstringens, A. sieberiana, Prosopis cineraria, to survive 5 weeks of drought that started the day they were planted. This method is not widespread but it is worth testing in a variety of other sites.

Direct sowing: Direct sowing is a simple and cheap technique which remains, however, limited to the more drought-resistant species. Acacia senegal, with the very quick growth of its taproot system, is particularly well suited for this technique. Direct sowing of A. senegal is very common in the Sudan. In Western Africa it has been used more or less successfully. Success depends largely upon a very careful use of the technique. In addition there are several prerequisites for it to be applicable:

- the soil must be initially cleared of all natural plant cover, and tilled. The soil is mellowed either locally (sowing in holes or in lines), or preferably over the whole surface (indispensable for broadcast sowing);

- seeds can be sown after 50 mm cumulative rainfall, and total rainfall must amount to at least 250 mm from germination to the end of the rainy season; in view of the highly irregular rainfall that seems to prevail, the latter point is difficult to forecast in any reliable fashion;
- intensive tending must reduce the competition of the natural plant cover, and control the parasites hidden amongst the weeds;
- efficient protection against fire and cattle is required for 3 to 5 years.

After 4 to 8 weeks it is necessary to thin the young plants so as to leave only one or two per hole, and 2 to 3 plants every 4 m (in line or broadcast seedings). The last thinning must be carried out one to two years later.

In view of the intensive tending required in direct sowing operations, this technique is characteristically advocated for rural areas where trees are planted in combination with crops. The following research is needed to improve the technique:

- to develop simple preliminary scarification techniques for use in rural areas, with a view to accelerating germination and making it more homogeneous, as well as to saving seeds;
- to coat the seeds with insect- and rodent-repellent products after the preliminary scarification treatment;
- to sow pregerminated seedlings.

Direct propagation by cuttings: In the current practice, this method concerns only a small number of species:

Commiphora africana, Euphoria balsamifera, Jatropha curcas, Tamarix spp.

According to the available literature other species such as Salvadora persica can also be candidates for it. Tests are needed in order to extend this technique to other species.

314.6 Plantation protection

Against fire: It is an established fact that fire-breaks are indispensable and need to be maintained - consequently it is not necessary to dwell upon this point. However, it should be pointed out that tests could usefully be conducted in the context of large-scale projects on the use of systematic contact herbicides in fire-break establishment. These products are easily applied with capillary application systems to kill the herbaceous cover upon coming into contact with it. Very little herbicide is needed to treat extensive areas of adventitious plant growth, without soil exposure to wind erosion, as opposed to the technique for cleaning bare strips. It might be interesting to compare the efficiency and price of the herbicide method and of the bulldozer or grader cleaning method.

Against cattle: It is an absolute prerequisite to protect plantations against animals in areas where there is less than 700 mm rainfall, even if the species planted is reputed to have little or no appeal (Eucalyptus camaldulensis, Azadirachta indica): indeed, starting from a given degree of drought and for certain animals, particularly goats and dromedaries, the desirability of a plant is no longer relevant - then, if the leaves are not attacked, the branches or the bark are eaten.

It is necessary to look into protection systems in order to define the least costly (in view of re-use possibilities) and the best suited to each plantation type:

- URSUS type grid
- FERLO type fence
- barbed-wire fence with the addition of a zeriba along the lower portion of the fence
- electric fence powered by light batteries (inextensively tested up to date in dry tropical Africa)
- Euphorbia or agave quickset hedges
- chemical repellents (seldom tried in dry tropical Africa)

Phytosanitary protection: It can be briefly recalled that in certain regions termite attacks are very serious, and that species such as Eucalyptus are extremely susceptible to them. Until recent years, an efficient and highly remanent product, dieldrin, was much in use, but other products are currently being developed as dieldrin is now a prohibited product in the USA and in Europe and might consequently be no longer sold. Alternative products need to be tested. It should be noted that deep-planting approaches, as described in 314.5, make the plants more termite-resistant (according to results of a test conducted in Senegal).

314.7 Tending

In dry areas tending is directly related to water economics. Tending intensity, frequency and efficiency vary according to virtually every species and to local ecological conditions. The impact of tending on cost prices and on the organization of work is significant. The following categories can be separated:

- tending by hand: this is appropriate for small plantations and rural-type plantations, and is also needed to supplement mechanized tending in large-scale plantations.

- mechanized tending: tending mechanization cannot be avoided in large-scale plantations where operations need to be carried out in a very short time.

  A comparative test on Azadirachta indica carried out in Niger, showed that after 17 months, mechanized and manual tending yielded similar results. Selecting one or the other method is dependent solely upon available means.

- chemical tending: this method is not yet widely used; at the present stage it applies only to large-scale reforestation. The best results are achieved with pre-emergence herbicides (which thwart weed germination). The herbicide is sprayed over damp soils prior to or shortly after planting. Pre-emergence herbicides that are used currently are active for 2 to 4 months if they are sprayed on originally clean soils. In such cases it is possible to prevent the growth of adventitious weeds during the rainy season following the planting. These are the results of pilot tests and operations; costs remain to be defined and compared to those of other types of action.

- tending combined with inter-cultivation: the taungya method and kindred systems, consisting in allowing farming activities between tree lines, make it possible to save the cost of first - and sometimes second-year tending (cost borne by the farmers). In these cases when rainfall levels are below 700-600 mm, wood yields decrease as compared to yields of above-mentioned tending methods because of the competition for water. But no survey has been made to determine whether the yield decline is offset or not by cost reductions.

  State managed temporary combinations of farm-crops and woody plantations amount to cumbersome and labour-intensive operations. However, there is no information available for comparisons of the economic value of such efforts and of projects based on "wood speculation" alone.

- tending in the form of grazing: few tests have been performed in this field. Possible research should aim at specifying the conditions under which this approach might be implemented, in particular the age at which it can be applied, acceptable cattle numbers....

- tending limited by mixing woody species: the principle is to combine species that provide a poor cover but that are in demand for the products they yield (for instance *E. camaldulensis*) with species producing a large canopy at a very early time (for instance *A. holosericea*). Little has been done in this field. Research should attempt to define the most efficient combinations, the optimum composition of the species mix, spacing distances, rules for stand management, etc. If it were possible to reduce tending requirements, rural-type plantations would greatly profit by the alleviation of what is now their major constraint.

314.8 Stand management

When trees are planted for the production of fuelwood, spacing lengths are not variable and felling cycles are short. To manage them means to define exploitation modes, felling-cycle durations and numbers, and to manage the coppice. Research carried out in this field has been centered around *E. camaldulensis*, the mosty widely used species in large-scale plantations. But some work has also been done on other exotic species as well as on local species, in Senegal - in particular on fodder acacias and Australian acacias (A. senegal, A. seyal, A. tortilis, A. holosericea, A. trachycarpa).

Various tests have shown that exploitability times vary according to the species, to the provenance, to planting densities, to rainfall levels, but to an even greater extent according to soil types. Thus, for the best E. camadulensis provenances with 4 x 4 spacing, and with a rainfall range of 600 to 800 mm, initial exploitation can take place at 4 to 5 years of age, depending on soil quality. In tests conducted on E. camaldulensis, observations were made only for clear-felling, the type of exploitation that is compatible with large-scale planting. These tests showed that under the above-mentioned rainfall conditions the time of exploitation seems to have no impact on the stooling capacity of this species. The age and thinning intensity of the stools have also been studied in E. camaldulensis; however, in view of the fact that most plantations are still relatively young research can seldom apply to more than the second felling cycle.

There is still much to be done in the field of stand management, given the recent trend towards diversification of reforestation species and the moves in favour of rural-type forestry. For the major species the following points need to be examined:

- coppicing techniques for the promotion of stooling,
- coppice management (date and intensity of stool thinning),
- coppice selection techniques (intensity and frequency of cutting runs),
- the most appropriate exploitation techniques for fodder-producing species (pollarding, trimming),
- biomass productivity.

315. Irrigated planting

The following is a succinct analysis based on the recent experience[1] of an experimental unit and of development areas in Niger and Senegal.

315.1 Irrigation method

Spray irrigation has proved to be ill-suited to the Nianga-Senegal areas where soils undergo considerable compaction. However, this method is appropriate for short irrigation periods, as it can be used very flexibly, for example in the first year after planting to enable the root systems of young trees to reach a ground water table close to the surface. The spray technique does not require much ground preparation; it can be very helpful in cases of tree-and-crop combinations (market gardening in the dry season, fodder in the rainy season).

---

[1] In Niger development started initially in 1965 but significant research work really began only in 1974; projects were launched in 1980. In Senegal the experience dates back to 1980.

Localized pressure irrigation: drip system, and the SETI Bas-Rhône system.

These systems, which require considerable investment in hydraulic equipment but little ground preparation, can be used under the following conditions:

- when the relief makes gravitation-based management too costly,
- when the relatively high filtration of the soil causes water supplies to be limited and fragmented to avoid water wastage,
- when irrigation water is expensive.

At Nianga, Senegal where none of these conditions are fulfilled, this system did not appear to be the most convincing. On the other hand, it provides the best irrigation efficiency on the rather uneven terraces of the Niger valley (Namarde goungou).

The SETI Bas Rhône system, whereby water supplies can be identified and regulated, appears to be an interesting experimental device, and for this reason is used in several silvicultural tests (irrigation-water dosage and frequency tests, spacing tests..)

Irrigation by flooding: This technique is well known in rice-fields, which must be permanently flooded. For trees, flooding periods must be short and repeated, in order to prevent tree asphyxiation. An adequate distribution of water requires the surface to be very accurately smoothed out - a costly operation. In view of the intermittent nature of the irrigation (periods of 7 to 15 days between two floodings), water consumption levels are considerable, since the deeper soil horizons must be filled again at every flooding. This technique can only be applied on small plots where there is plenty of available water; it is appropriate for very high density plantations.

Furrow gravity irrigation: Up to date this method has given the best yields and in addition it is easily implemented. Over 90 m stretches it ensures as good a distribution of water as the drip method. Lastly, within the context of the Senegal valley, it is undoubtedly the most appropriate method as regards the economic requirements of wood production.

315.2 Silvicultural techniques

Planting time and mode: If one controls the water supply one has great freedom as regards planting time. According to observations make on E. camaldulensis it seems that the best time to plant is at the beginning of the hot wet season. For organizational reasons (labour availability) it might be advisable, however, to change the time of planting. Relevant tests are being carried out. Tests comparing the behaviour of stumps and of bagged plants are also underway. Stumps are interesting because of their low production costs and of their considerable flexibility in terms of nursery raising and of utilization (see 313).

Irrigation dosage and frequency: In view of the problems encountered by projects in the field of water supply management, a majority of experiments on this point have not been carried out under proper conditions. Controlling water supplies is a crucial factor which must be properly implemented in future experiments. Current practice in the Nianga-Senegal area includes water supplies amounting to estimated totals of:

- 1200 to 1500-2000 mm/year, the frequency being once a week for 40 weeks in furrow gravity irrigation,
- 3500 to 7000 mm/year in irrigation by flooding.

Spacing, biomass productivity: With furrow gravity irrigation, a planting density of 5000 plants/ha (2 x 1 m) seems optimal for the economics of pole-wood production. In Nianga-Senegal, a 35.4 m^3/ha/yr average productivity was obtained at 2 1/2 years with a density of 4444 plants/ha and irrigation water applied at some 2000 mm/yr. These results, achieved on favourable soils (clay-and-silt texture), need to be confirmed under less favourable conditions.

Exploitability age, coppice management: Research is in progress in this field, in particular in Nianga-Senegal, where various exploitation ages are being studied, in a plantation where the density reaches 5000 plants/ha (with furrow gravity irrigation), as well as the number of stools to be selected after each felling run.

Non block-planting configuration: Several types of configurations were tested at Nianga-Senegal:

- windbreaks combining E. camaldulensis and A. holosericea (spacing 2 x 2 m) giving satisfactory results.

- in tree-and-crop combinations a rather marked depressing effect of E. camaldulensis was noted in the garden crops, probably due to excessive tree density (6 x 1 m). The technique involved was furrow gravity irrigation. Poor results were recorded with the spray technique for most fodder crops (millet, panicum, sorghum), because of soil compaction. Niebe alone showed satisfactory behaviour in spite of low productivity levels.

The silvicultural research necessary in the field of irrigated planting still has a number of points to look into:

- to study irrigation rate and frequency from season to season -including a study on the need for water rationing during the vegetative dormancy period (cool and dry season)

- study of fertilization (time of ferti'ization, rate)

- study of water balances in connection with percolation observations

- as regards the furrow gravity irrigation method, a study of the distribution of water according to soil types and furrow characteristics (length, gradient, profile). Study of scope for extrapolation of experimentally produced results to large plots (irrigation furrows longer than 150 m)

- in the context of saline and development, tests of salt-resistance in certain species.

As in dry planting test sites must first be characterized according to a standardized method (see 311) if results are to be fully interpreted and extrapolated.

32. Knowledge dissemination and training needs

321. Knowledge dissemination

Here there are two different aspects depending on the target group concerned:

- the dissemination of technical and scientific information, intended especially for engineers, highly qualified technicians and researchers

- the popularization of knowledge for the benefit, chiefly, of field workers and of the public at large.

Both aspects are essential contributors to improvements in silvicultural techniques and in forestry development in general. There are close links between knowledge dissemination and personnel training. Technical and scientific innovations described in publications can only be of real use to the reader if he can update his knowledge regularly - this is often problematic in tropical areas where a majority of technicians of any field suffer from varying degrees of isolation from scientific knowledge. Likewise, popularization can only be contemplated if the techniques are appropriate and well under control, which calls for innovative capacities and good training standards.

321.1 Technical and scientific information dissemination

Publications: For dry tropical Africa as for all other parts of the world, technical and scientific information sources are highly diversified. It is a specialist's job to keep informed about all the latest publications concerning the region, in the forestry field alone. Few local documentation centres (with Forestry Departments, research institutes, training centres, etc.) are adequate to the task. A major synthesis effort has been made and is continuing to be made by FAO; in particular by means of the FAO collection of Forestry Papers, several of which concern dry tropical Africa. CILSS has also issued a number of interesting bibliographies on rural development, but none of them address silvicultural techniques. Region-specific technical publications do exist but experience shows that several ones are not adequately known. The same is true of scientific or technical journals, conference and workshop reports, etc.

To improve this situation it is proposed to publish analytical bibliographies similar in form to "Forestry Abstracts" but specific to dry tropical regions and limited at first to the field of nursery and plantation techniques.

These bibliographies, published in French and English, could progressively cover other forestry disciplines where information needs are similar, if the experiment is successful. They should be circulated as widely as possible amongst forestry departments, projects, research institutes, training centres in dry tropical Africa. Drawing up such analytical bibliographies might be entrusted to an international organization which is well endowed with data in relevant fields (FAO, IUFRO), or else to the Commonwealth Agricultural Bureaux, publishers of Forestry Abstracts. In the latter case, CAB might produce "special issues" of Forestry Abstracts (in French and English) at intervals of, perhaps, every three years. They should be publicized widely in the international community of forestry researchers and technicians so that journal publishers, authors of papers, and symposium organizers make sure, as a matter of course, that they record any new material of interest to dry areas with the relevant appointed institution.

Other information sources: National institutions and projects have a sizeable stock of unpublished information in the form of technical notes, reports, etc. and even in the form of orally conveyed knowledge. Here the degree of dispersion matches the great number of research and development activities. It is extremely difficult, today, to have a general picture of all current forestry action concerning dry Western African countries - let alone the whole of dry tropical Africa. Projects with identical objectives, environmental conditions and technical problems, have virtually no chance of making contact if the countries of implementation and the funding agencies are different. This situation is still more prevalent as regards research programmes carried out between countries.

CILSS sectorial studies (forestry sector analyses and proposals) which exist in certain countries[1/] contain a vast amount of information. To generalize these analyses to the whole of dry tropical Africa and to update them on a regular basis would be a way of remedying the above-mentioned difficulties - but at the cost of a considerable financial effort.

It would be possible to produce only a directory of all the forestry management operations in dry tropical Africa with some reference to their major characteristics, in order to give an indispensable general picture and to identify respective fields of competence. The benefits expected from improved flows of information include time savings and a better use of resources for researchers, technicians, decision-makers, finance providers and government officials.

FAO is developing a Compendium of Forestry Research in Africa from responses to two questionnaires. A draft catalog giving information on research institutions in 32 countries has already been created. To attain their goal, they need to acquire some supplementary information.

All this information could appear in a directory of forestry research in dry tropical Africa; in addition, preparation of a directory of forestry

---

1/ Burkina Faso, Cape Verde Islands, Mali, Mauritania and Niger.

development in dry tropical Africa is beng prepared[1]. This latter could contain:

- a part on national structures in charge of forestry research management: the forestry department of each nation;
- a part on forestry projects and on projects with a forestry component.

These documents, to be updated on a regular basis (perhaps every 3 to 5 years), would contain descriptive sheets for each research institute, forestry department or project; the sheets would include the following data:

- legal status, objectives,
- position within the overall organization of rural development and research of the country concerned, relevant ministry, possible organic links with research institutes in the fields of farming and animal husbandry, with higher education institutions and with rural development departments
- funding arrangements, budget, term of operation
- organization chart, geographic location
- major fields of action (programmes, technical divisions) with an indication of human and material resources involved
- researchers, technical supervisors (names, qualifications, positions).

The directory of forestry research in dry tropical Africa could be prepared fairly easily from the data already assembled by FAO for the Compendium of Forestry Research in Africa. Additional resources would be necessary, however, to collect missing data and publish the document.

The task of preparing the directory of forestry development in dry tropical Africa can be entrusted to FAO or to one of the major international funding agencies (World Bank, FAL, CROI, GTZ...).

The directories should be circulated as widely as possible both inside the countries concerned and outside Africa. It is worth recalling that there already is, in the field of education, a list of forestry schools, drawn up by FAO at the global scale - FAO Technical Paper No. 3.

It is also proposed that research and development funding agencies provide funds and staff for the publication of results, in any new project.

---

[1] The directories should include all the countries implicated in the Nairobi Conference. In addition to the 10 countries described in this study -Burkina Faso, Camoroon, Cape Verde Islands, Chad, Gambia, Mali, Mauritania, Niger, Nigeria, Senegal, there are 6 other - Djibouti, Ethiopia, Kenya, Somalia, Sudan and Tanzania.

321.2 Knowledge popularization (extension)

Very little has been done in this respect as compared to the magnitude of needs. As regards silvicultural techniques there should be two aspects in popularization:

1) To make technical innovations and research results accessible to field staff involved in development work

2) To disseminate reliable techniques amongst populations.

Until now research institutes have mainly concentrated on publishing technical documents, whilst forestry departments have usually not had the means to do much more than enforce the forestry code in areas outside the reserve forests. Apart from its strictly technical aspect, extension work in rural areas is chiefly a matter of changes in attitudes and in forestry policies. In this respect, the situation may change faster if field technicians are regularly retained, thus enabling new relationships to appear between the forestry people and the populations. The small number of popularization efforts carried out to date have generally fallen under the general heading of forestry in rural areas, a policy very actively supported by external funding agencies in the past few years.

Popularization must be designed specifically for the target groups. In the field of silvicultural techniques it can take a variety of forms:

- publishing handbooks that describe techniques or specific problems; they would be intended for field staff (technicians, supervisors, technical assistants) and should consequently be simple and attractive to read, with many illustrations, in order to be truly didactic

- frequent but short practical demonstrations in nurseries and in pilot plantations, intended for field staff as well as for local populations

- information meetings for the populations to be made aware of specific problems, such as the need to protect the trees against fire and cattle.

Adequate means should definitely be devoted to the publishing of practical handbooks; indeed the books must be produced for wide circulation, according to high quality standards and to a solid technical basis.

Such handbooks can include data sheets on the following themes:

- preliminary germination treatment
- sowing methods
- transplanting methods
- soil mixtures in nurseries
- shade provision for young plants
- stumps production
- post-nursery plant selection
- precautions in transporting the plants

- selection of planting site
- ground preparation techniques
- planting techniques
- spacing
- weeding techniques
- felling techniques
- stool thinning procedure
- coppice management

etc. etc.

322. Training

In the countries under review there are forestry schools at various levels:

- higher education level (schools listed according to the alphabetical order of the countries)

Institut supérieur Polytechnique* - Ouagadougou - Burkina Faso

École nationale supérieure agronomique - N'Kolbisson - Cameroon

Institut polytechnique rural de Katibougou* - Mali

École supérieure d'agronomie et d'élevage de Niamey* - Niger

Department of Forest Resources Management Faculty of Agriculture and Forestry - Ibadan - Nigeria

Department of Wildlife and Range Management Faculty of Agriculture and Forestry - Ibadan - Nigeria

Department of Forestry and Fisheries, University of Sokoto* - Nigeria.

- other educational levels

École de préposés forestiers - Dinderesso - Burkina Faso

École pour la formation de spécialistes de la faune* - Garoua - Cameroon

École des Eaux et Forêts et des Chasses - Mbalmayo - Cameroon

Centre de promotion du bois - N'Kolbisson - Cameroon

Institut polytechnique rural de Katibougou* - Mali

Centre de spécialisation forestière de Tabakoro - Mali

Centre de formation agricole* - Kaedi - Mauritania

Institut pratique de développement rural* - Kolo - Niger

Benin Forest Utilization Centre - Benin City - Nigeria

School of Forestry - Ibadan - Nigeria

School of mechanization - Afaka - Nigeria
École nationale des cadres ruraux* - Bambey - Senegal

École nationale des agents techniques des Eaux et Forêts - Zinguinchor - Senegal

Institut du développement de Thies - Senegal.

The names with an asterisk are schools located in the North Sudanese or Sahelian zones, which does not necessarily mean that what they teach is specific to problems of those areas. In Burkina Faso and in Mali for instance, graduates from these schools may be posted to the southermost areas of their countries; conversely, in Cameroon and Nigeria higher institutions for the training of future forestry executives for the Northern areas are located in wet zones.

There are no forestry schools in the Cape Verde Islands, Gambia and Chad. The tuition offered in the above-mentioned institutions is generally adequate, although they often lack practical training capabilities. A number of measures would however make it possible to make the system more efficient:

1) Annual or biannual one-week meetings of directors in charge of curricula in the schools that are more directly concerned by dry area problems, in order to better define curricular approaches and contents. For these purposes, such meetings should be held in cooperation with major international and regional organizations (FAO, IUFRO, Sahel Institute) which would help to update basic documentation.

2) Teacher training sessions can be organized during the school holidays on specific themes; they might include visits to research units and project sites.

3) End-of-course training sessions with national research structures should be promoted in order to make technicians-to-be aware of the stringent requirements of research, while reinforcing the field support for research.

4) Research and development funding agencies should make provision in any new project for scholarships intended to enable the researchers and technicians in charge of the projects to become fully trained and to produce work and reports to match project objectives.

Once they become operational, forestry workers and supervisors have far fewer opportunities to update their knowledge. Continuing retraining cycles (generally organized in the context of projects) are infrequent and concern only a small percentage of the staff,[1] although this is a priority, as was discussed in the paragraphs above.

It is proposed to set up, in most countries, a permanent retraining unit responsible for a continuous provision of courses for forestry staff working in dry areas. These units would be given the means to operate autonomously but would be linked with educational institutions located in dry areas, for the purpose of improved coordination with existing training programmes.

In Senegal, additional resources might be provided for the centre under the PARCE project[1] to become a regional centre. The work of this Senegal centre might be used by the Cape Verde Islands and Gambia, where the small number of forestry employees does not justify setting up a training unit.

Likewise, there could be a joint centre for staff from Niger, Chad and Cameroon, located with ESA in Niamey; indeed Chad has no training infrastructure and Northern Cameroon numbers only a few forestry employees.

As regards the four remaining countries, Burkina Faso, Mali, Mauritania and Nigeria, national training centres could be opened respectively in Ouagadougou, Katibougou, Kaedi and Sokoto.

The number of teachers and the resources for each centre should be proportionate to the number of trainees. All locally available forms of expertise, from national structures and from projects, should be involved in order to supplement the training provided by the teachers of these centres. Each centre should organize 7 or 8 two-to-three week training courses per year for various professional categories: engineers, technicians, technical assistants, instructors, etc. Each course could be designed to train some 15 people, and would include theoretical lessons as well as practical demonstrations in nurseries and on project sites.

Three types of preliminary projects are proposed:

- Preliminary projects intended to raise the general level of knowledge and improve the dissemination of scientific and technical information:
    - Preliminary project no. 1: Continuing training for forestry personnel. It is concerned with all forestry disciplines
    - Preliminary project no. 2: Development of analytical bibliographies specific to dry tropical regions. This has been limited to the field of nursery and plantation techniques but could be expanded to other fields where similar needs exist, if the experiment is successful
    - Preliminary projects nos. 3 and 4: Directories of research and development in dry tropical Africa. What is needed is to produce workable communication tools both for research and field workers in all forestry disciplines and for decision-makers and financial and policy managers.

---

[1] Only Senegal, with two centres for continuing training, is an exception to this rule. The larger of these centres is funded by FAO - World Bank - French cooperation, in the context of the PARCE project.

- Preliminary analytical projects, divided into several phases:
  - Evaluation of existing techniques and practices for:
    - Publication of technical data sheets and popular extension manuals covering all information judged to be reliable
    - Identification, planning and implementation of new research activities

These preliminary projects concern nursery techniques (No. 5) and plantation techniques (No. 6).

- Preliminary projects that are strictly technical:
  - No. 7: Development of a site description method
  - No. 8: Hardening of tissue-cultured gum acacias under Sahelian conditions

IV PRELIMINARY PROJECTS PROPOSED

PROJECT NO. 1

Title of Project	CONTINUING TRAINING FOR FORESTRY STAFF
Justification	See para. 322
Objectives	To establish units for continuing training of national forestry staff at all levels (research engineers, project engineers, technicians, technical assistants, instructors?) and operate them for 5 years. The instruction dispensed in these centres should extend to all forestry disciplines: genetic improvement, nursery techniques, silviculture, management of plantations and natural vegetation, agroforestry, etc. It is proposed to attach these units to already existing bodies (the most appropriate agency in the country concerned, preferably a training school). These units should bring together teaching, research and development; their activities should take into account the existing teaching levels and programs, research results and development needs.
Duration	Project in two phases: - First phase, evaluation and preparation of the project - Second phase, operation for a five-year period
Organization Proposed for Implementation	The final choice of location for the training units will be made when the project documentation is being prepared, after an evaluation mission has studied in detail the situation and problems arising in each country. As a first approximation taking into account the potential host organisms and the personnel to be retrained, it is proposed to establish continuing training units within the following organisms: - Institut supérieur polytechnique of Ouagadougou for Burkina Faso - Institut polytechnique rural of Katibougou for Mali - Centre de formation agricole of Kaedi for Mauritania - École supérieure d'agronomie et d'élevage of Niamey for Niger, Chad and North Cameroon - Department of Forestry and Fisheries University of Sokoto for Nigeria

- Centre de formation continue du projet PARCE (FAO project already operating) for Senegal. This centre could be a joint centre for staff from Cape Verde, Gambia and Senegal.

Activities

First phase of the project: Evaluation and preparation of project document. Such a document should:

- accurately assess the situation in every country as far as continuing vocational training is concerned
- mention the opinions and wishes voiced by forestry administrations concerned by the project
- identify the problems that might hinder project implementation.
- assess accurately which positions of personnel need retraining in each country and at each educational level
- state the number of centres to be set up, where they should be located, what training personnel and equipment would be needed. Such needs, which are proportionate to the number of employees to be retrained, will vary from one centre to the next. An "average centre" is used here as the basis for an estimate under the heading 'Budget'
- outline an implementation programme and schedule for every centre
- Second phase of the project: Establishment and operation of training units for five years. The major stages are as follows:
- Recruiting and establishing training teams.
- Defining and implementing a yearly training schedule for each unit. Units should all be able to offer 7 or 8 two- to three-week training courses a year, at different levels. Courses could involve approximately 15 trainees and consist of theoretical classes and practical applications in nurseries and on project sites. All local specialists would be called upon to supplement the courses given by the units.
- Setting up a one-week workshop to bring together all the training teams at the end of the second year of the project.

Budget (estimate) in thousands of CFA francs for an "average centre"

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Equipment:						
Office, class-room	12 000					12 000
Furniture, office equipment	4 000					4 000
Teaching materials, documentation	3 000	250	250	250	250	4 000
Service car	3 500			3 500		7 000
Minibus	10 000					10 000
Staff: (salaries, various allowances and housing)						
Expert	30 000	30 000	30 000	30 000	30 000	150 000
Assistants	7 000	7 000	7 000	7 000	7 000	35 000
Typist, driver, porter	1 500	1 500	1 500	1 500	1 500	7 500
Occasional consultant work	2 500	2 500	2 500	2 500	2 500	12 500
Travelling allowances for trainees from other countries	2 000	2 000	2 000	2 000	2 000	10 000
Operational costs:						
Service car	1 500	1 500	1 500	1 500	1 500	7 500
Minibus	2 500	2 500	2 500	2 500	2 500	12 500
Upkeep of buildings and maintenance of machines	300	300	300	300	300	1 500
Miscellaneous	300	300	300	300	300	1 500
Overheads	3 000	3 000	3 000	3 000	3 000	15 000
Sub-total						
In thousands of CFA fr.	83 100	50 850	50 850	54 350	50 850	290 000
In US dollars	207 750	127 125	127 125	135 875	127 125	725 000

Budget for the overall project in thousands of CFA francs (estimated)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Project document preparation							
Visit of expert to the 10 countries concerned, drafting and publishing a report (3 mo.)	12 000[1]						12 000[1]
Domestic and international travelling	2 000						2 000
Miscellaneous	500						500
Workshop							
Daily subsistance allowances, travelling expenses of the participants, organization costs, publishing of the final report			15 000				15 000
Operational costs of retraining centres of							
Ouagadougou, Katibougou, Kaedi, Niamey, Sokoto		416 000	255 000	255 000	272 000	255 000	1 453 000
Strengthening of the Senegal retraining centre		40 000	25 000	25 000	25 000	25 000	140 000
TOTAL in thousands of CFA fr.	14 500	456 000	295 000	280 000	297 000	280 000	1 622 500
in US dollars	36 250	1 140 000	737 000	700 000	742 500	700 000	4 056 250

Contribution by the countries concerned:
- provision of land
- salaries and daily subsistance allowances of the trainees

---

[1] Cost including salaries, daily subsistance allowances and miscellaneous costs.

PROJECT NO. 2

Title of Project	PREPARATION OF ANALYTICAL BIBLIOGRAPHIES SPECIFIC TO DRY TROPICAL REGIONS IN THE FIELD OF NURSERIES, PLANTATION ESTABLISHMENT AND MANAGEMENT
Justification	See paras. 321 and 321.1
Objective	To improve the dissemination of technical and scientific information to research and development organizations in dry tropical regions. The bibliographies are limited to the fields of nursery techniques and establishment and management of plantations, but similar needs exist in all other forestry disciplines. As experience becomes successful the fields covered by these bibliographies can expand progressively to include other disciplines.
Duration	- 12 months for the preparation of the first edition - 3 months every 3 years for the following updated editions.
Organizations Proposed for Implementation	An international agency with a large stock of relevant data (FAO - IUFRO). The Commonwealth Agricultural Bureaux, publishers of Forestry Abstracts, may also be in a position to publish this type of bibliography as "special issues" in English and French.
Activities	1) To draw up bibliographic lists and to analyze documents: this can be done by forestry students in the course of graduation training or of doctorate preparation, as well as by junior graduates under the supervision of a senior forestry professional. 2) Publishing and distribution. 3) Updating every 3 years.

Budget in US dollars (estimate)

		Year 1 1st edition	Every 3 years from Year 4 (for the following editions)
Purchase of documents		2 000	
Personnel:	student trainee or junior graduate	28 000 (12 months)	7 500 (3 months)
	Coordinator	7 000 (1 month)	3 500 (0.5 month)
	Secretarial assistance and communication (telex, telephone and mail)	2 500	700
	Publishing and distribution	4 000	2 500
	Miscellaneous	1 500	800
TOTAL in US dollars		45 000	15 000

PROJECT NO. 3

Title of Project	DIRECTORY OF FORESTRY RESEARCH IN DRY TROPICAL AFRICA
Justification	See paras. 321 and 321.1
Objective	To give an overall picture of forestry research activities in the region and a better identification of respective fields of competence. The project is expected to promote improved circulation of information among researchers, foresters, decision-makers, fund providers and government officials in order to save time and to use resources more efficiently.
Duration	Preparation of the first edition in the first year (on a part-time basis); publishing of an updated edition every 5 years.
Organizations Proposed for Implementation	FAO is currently working on a Compendium of Forestry Research in Africa. A draft catalogue giving information on research institutions in 32 countries has already been prepared, based on responses to two questionnaires (1980 and 1983). The supplementary resources requested would enable acquisition of missing information and preparation of the document in its final form.
Activities	1) To prepare an enquiry form to be sent to research centres for which data are still lacking. This for would be used to collect information on: - legal status, aims pursued - position within the overall organization of research and rural development in the country concerned (relevant ministry; organic ties, if any, with farming and animal husbandry research institutions, with universities and rural development departments) - funding modes, budget, period of activity - organization chart, geographical location(s) - major fields of activity (programmes, technical departments), with an indication of the human resources and equipment involved - researchers, technical supervisors (names, qualifications, duties) 2) To send the enquiry forms to research centres; correspondence with the centres.

3) To organize the information collected with the help of a consultant - duration: 1 week.

4) To publish and distribute the document.

5) To update the document every 5 years.

Budget in US dollars (estimate)

		Year 1 1st edition	Every 5 years from Year 5 (for the following editions)
Personnel:	Consultant[1]	5 000 (0.5 month)	5 000 (0.5 month)
	Coordinator: liaison with research centres	7 000 (1 month)	5 300 (0.75 month)
	Secretarial assistance and communication (telex, telephone and mail)	1 500	1 200
	Publishing and distribution	4 000	4 000
	Misc. expenses	2 500	2 000
TOTAL in US dollars		20 000	17 500

---

[1] Cost including salaries, daily subsistance allowances, miscellaneous costs

PROJECT NO. 4

Title of Project

DIRECTORY OF FORESTRY DEVELOPMENT IN DRY TROPICAL AFRICA

Justification

See paras. 321 and 321.1

Objective

To give an overall picture of forest development activities and a better identification of respective fields of competence. The results expected are: better circulation of information among researchers, foresters, decision-makers, fund providers and officials and consequently, time savings and improved efficiency of resources.

Duration

During the first year (on a part-time basis) preparation of the first edition; publishing of an updated edition every 5 years.

Organizations Proposed for Implementation

An international organization: FAO, World Bank, or a major cooperation agency; FAI, CRDI, GTZ, etc.

Activities

1) Most international organizations and cooperation agencies already have their own catalogue of the projects that concern them. These are almost all for internal use, if not confidential. Consultation with these organizations, with national forestry departments, with NGOs etc. will be needed, to:

- define the format and content of a document for wide distribution
- establish a list of forestry projects, or projects with a forestry component, operating in each country.

2) To prepare, on the basis of the criteria established and in consultation with the main bodies concerned, an enquiry form to be sent to development organisms in the various countries (forestry services and projects)

The information to be given in the directory might concern the following items:

- legal status; aims pursued

- position within the overall organization of research and rural development in the country (relevant ministry; organic ties, if any, with farming and animal husbandry research institutions, with universities and rural development departments)

- funding modes, budget, period of activity

- organization chart, geographical location(s)

- major fields of activity (programmes, technical departments) with an indication of the human resources and equipment involved

- researchers, technical supervisors (names, qualifications, duties)

3) To send the enquiry forms to forest departments, projects, financing agencies, etc.; correspondence with them.

4) To organize the information collected with the help of a consultant - duration: 3 weeks

5) To publish and distribute the document.

6) To update the document every 5 years.

Budget in US dollars (estimate)

		Year 1 1st edition	Every 5 years from Year 5 (for the following editions)
Personnel:	Consultant[1]	10 000 (1 month)	7 500 (0.75 month)
	Coordinator: liaison with development organisms, funding agencies	14 000 (2 months)	7 000 (1 month)
	Secretarial assistance and communication (telex, telephone and mail)	2 500	1 500
	Publishing and distribution	4 000	4 000
	Misc. expenses	2 500	2 000
	TOTAL in US dollars	33 000	22 000

1/ Cost including salaries, daily subsistance allowances, and social security costs

PROJECT NO. 5

Title of Project	NURSERIES: EVALUATION OF TECHNIQUES USED, DISSEMINATION OF KNOWLEDGE, PLANNING OF FURTHER RESEARCH
Justification	Para. 313
Objectives	- To survey and assess nursery raising techniques in dry tropical zones for each species or group of species. On the basis of this evaluation: - To publish technical data sheets and extension handbooks on the techniques considered reliable and appropriate - To identify new research subjects and prepare the project documentation for them - To carry out the proposed research
Duration	- 12 months for a student and expert, 2 months for a coordinator, for the first three phases of the project - 3 to 5 years for the research contracts (phase 4 of the project)
Organization(s) Proposed	To implement phases 1 - 3: to be specified To implement the research contracts (phase 4): national research institutions
Activities	Four-phase project

Phase 1: Evaluation of existing techniques and practices

Major stages:

- To choose a representative number of nurseries to be studied bearing in mind production contexts (foretry department nursery, village-based or private nurseries), the species utilized and environmental conditions.
- To take stock of the techniques used through bibliographical surveys. To draw up detailed data sheets for each species or group of species.
- As is mentioned in para. 313, several research centres are in the process of drawing up such data sheets. Financial support would encourage such efforts. A total allocation of $50 000 US might be distributed to institutions according to the draft data sheets which they would propose.

- To prepare a questionnaire as a basis for detailed analysis of current techniques.

- To conduct a field survey of commonly used techniques and of current research. This should be done in close collaboration with national research centres (if any).

Phase 2: Distribution of technical data sheets and extension manuals based on data collected in Phase 1

- To handle technical forms as outlined in phase 1 (by means of bibliographic searches to be supplemented from any new information source: publications, unpublished documentation, data sheets produced by institutes, data collected during the survey work).

- To compile technical data sheets from these forms, which should specify clearly:

  - the techniques deemed reliable and appropriate
  - current research efforts
  - needs for further research work.

- To attractively illustrated popular leaflets on all the techniques considered reliable and appropriate.

Phase 3: Preparation of project documents on the theme of research identified in phases 1 and 2

Each document should describe in detail the results already obtained on the same theme or topic, objectives, intended protocol, methods to employ. More generally, it should contain all the elements needed to conclude a contract between the funding agency and the institution responsible for its performance.

Phase 4: Performance of research contracts

The final list of research to be performed cannot be drawn up before the end of the evaluation mission described in phase 1. However, certain research themes have already been identified (see para. 313). For each of these, a rough estimate of budgetary requirements for a study period of 3-5 years is given below. Each budget includes the production of a final technical report.

Research Themes (not exhaustive)	Organization Proposed	Budget for 3-5 Years (rough estimate) US$
Ongoing tests on preliminary acid scarification particularly for the seeds of native species	CNRF, Senegal	7 500
To finalize simple seed scarification pretreatments suited to rural nurseries	DSF, Burkina Faso	7 500
To develop procedures for arresting germination and preserving seedlings in cool conditions	To be specified	15 000
To develop nursery techniques for problematic species (see para. 313)	Research contract maybe to be divided (depending on species) among several institutes (to be specified)	30 000
Ongoing tests on wet chamber propagation by cuttings of E. camaldulensis; extension of these to other species particularly to P. juliflora, A. indica, P. aculeata, native and Australian acacias.	IRBET/CTFT in Burkina Faso	25 000 (in addition to currently available resources)
To finalize misting techniques in propagation by cuttings of major species	CNRF, Senegal	25 000 (in addition to currently available resources)
To study stump production for P. juliflora, P. aculeata, A. holosericea and other species	To be specified	15 000
To determine early selection criteria for seeds of Eucalyptus camaldulensis	CRF, Cameroon	30 000
To finalize the seed coating technique for Eucalyptus seed	To be specified	15 000
To develop a type of compost trench for general use in rural areas	To be specified	7 500
	Sub-total phase 4:	177 500

Budget in US dollars, rough estimate, phases 1, 2 and 3

Phase 1	- To draw up a list of representative nurseries, questionnaires, bibliographic survey:		
	- Purchase of documents	500	
	- Personnel - trainee or junior graduate: 2 months	5 000	
	Coordinator: 0.25 months	1 750	
	Secretarial assistance and communication (telex, mail, telephone)	1 250	8 500
	- Support to national research institutes for drafting of data sheets		
	Funds for division among the various projects		50 000
	- Field evaluation of techniques and research in progress		
	Personnel - consultant[1]: 2 months	20 000	
	- coordinator: 0.25 month	1 750	
	International and local travel	6 000	
	Secretarial assistance and communication (telex, mail, telephone)	500	
	Miscellaneous expenses	750	29 000
	Sub-total phase 1:		87 500
Phase 2	- To prepare the data sheets		
	Personnel - consultant[1]: 1 month	10 000	
	trainee or junior graduate: 1 month	2 500	
	Coordinator: 0.5 month 3 500		

---

[1] Cost including salaries, daily subsistance allowances, and social security costs

Budget in US dollars, rough estimate, phases 1, 2 and 3 (cont'd)

		Secretarial assistance and communication (telex, mail, telephone)	500	
		Publishing and distribution	3 500	20 000
	-	To draft popular extension handbooks		
		Personnel - trainee or junior graduate: 3 months	7 500	
		Illustrator: 2 months	7 000	
		Coordinator: 0.75 month	5 250	
		Secretarial and communication expenses (telex, telephone, mail)	1 000	
		Publishing and distribution	5 000	25 750
		Sub-total phase 2:		45 750
Phase 3	-	Preparation of projects: research contracts with national institutes:		
		Personnel - consultant[1]: 1 month	10 000	
		Coordinator: 0.25 month	1 750	
		Secretarial assistance and communication (telex, mail, telephone)	500	
		Publishing and distribution	1 750	14 000
		Sub-total phase 3:		14 000

---

[1] Cost including salaries, daily subsistance allowances, and social security costs

PROJECT NO. 6

Title of Project

PLANTATIONS: EVALUATION OF TECHNIQUES USED, DISSEMINATION OF KNOWLEDGE, PLANNING OF FURTHER RESEARCH

Justification

Paras. 314 and 315

Objectives

Based on several experiences with reforestation, to evaluate the reliability of silvicultural techniques in relation to site characteristics and species used. Based on this evaluation:

- To distinguish the reliable information from what remains to be clarified. Draft popular extension manuals for everything in the former category. Identify topics that require new or increased research and prepare the requisite documentation.
- To carry out the proposed research.

Duration

- 22.5 months for experts in various disciplines (soil science, forestry, communications, illustration), 3 months for a coordinator for the first three phases
- 3-10 years for research contracts (phase 4 of the project).

Organization(s) Proposed

- To initiate phases 1-3: to be specified
- To initiate research contracts (phase 4): national research institutes

Activities

Four-phase project

Phase 1: Evaluation of existing techniques and practices

Major stages:

- To choose a number of plantation sites (about a dozen) that are notable for the number of species tested, the variety of silvicultural techniques used, the quality of technical monitoring and the storage of data.
- By means of bibliographic searches, to survey techniques in use. To prepare a data sheet according to types of technique. Financial support for research institutes would facilitate the work. Overall funds amounting to $50 000 are envisioned, to be shared among the institutes depending on the data sheets that will be produced.
- To prepare a questionnaire to permit detailed analysis of silvicultural techniques in use, especially the following:

- techniques of land preparation
- types of plant
- date and method of planting
- plant spacing
- fertilization
- tending: date and frequency

- To carry out a detailed field evaluation of silvicultural techniques in use and research under way. Interpretation of results will take into account site characteristics and plant material used. This will be done in close cooperation with national research centres, where they exist.

Phase 2: Distribution of technical data sheets and popular extension manuals prepared from data collected in phase 1

- Forms drawn up in phase 1 should be completed from any new sources of information (publications, unpublished documents, technical data sheets prepared by institutions, information collected by the evaluation mission)

- From these forms, to draft technical data sheets clearly presenting the following information:

  - Techniques recognized as reliable and appropriate
  - Research in progress
  - Relationships evident among sites, plant material and silvicultural techniques

- To prepare simple, attractively illustrated popular extension manuals in all fields of information judged to be reliable.

Phase 3: Preparation of project documents on research themes identified in phases 1 and 2

To prepare for each theme a project document designed as a basis for a research contract between the funding agency and the implementation institute. Each document will contain the following details:

- a clear description of the research theme and objective

- a synthesis of results already obtained in the relevant field

- preparation of the test procedure

- means required: the human resources, equipment and logistics that can be made available for the project by the implementation institute must be indicated.

Phase 4: Performance of research contracts

The final list of research to be carried out cannot be drawn up until the completion of the evaluation mission intended in phase 1. However, some research themes have already been identified (see paras. 314 and 315). A rough estimate of the budget required for each of these is given below. The budget includes publication of a final technical report.

Research Themes (not exhaustive)	Proposed Duration	Budget (estimate)
1. Rainfed plantations		
Study of practical and economic potential for early-season planting, involving additional watering (tests of various planting dates and various types of seedlings) (see para. 314.4)	3 years	20 000
Deep planting tests in various types of soils and with different species (see para. 314.5)	3 years	20 000
Direct sowing tests for repellent coated seeds (scarified or unscarified seeds) (see para. 314.5)	3 years	10 000
Direct sowing tests for pregerminated seedlings (see para. 314.5)	3 years	10 000
Direct propagation tests using cuttings of various species, particularly Salvadora persica (see para. 314.5)	3 years	7 500
Tests on, and determination of the operational cost of reusable fences, particularly the FERLO-type Senegalese fence and the electric fence powered by light batteries (see para. 314.6)	3 years	20 000
Tests on termite repellents substitutes for dieldrin (see para. 314.6)	3 years	20 000
Tests of species combinations designed to reduce tending (see para. 314.7)	5 years	30 000

Research Themes (not exhaustive)	Proposed Duration	Budget (estimate)
Study of the potential for regeneration by coppicing and coppice stand management for various species (see para. 314.8)	5 years	20 000
Study of the most appropriate utilization techniques for fodder-producing species (pollarding, pruning)	5 years	20 000
Study of the biomass yield of certain relatively fast-growing species (Australian acacias, *Prosopis juliflora*)	5 to 10 years	35 000
	Sub-total	212 500
2. Irrigated plantations		
Study of irrigation frequency and rates for each season. Assessment of the need to ration water in the vegetative dormancy period (cool dry season) (see para. 315.2)	5 years	25 000
Study of fertilization timing and rates	5 years	10 000
For furrow gravity irrigation, study of water distribution according to soil types and furrow characteristics (length, slope, profile)	3 years	25 000
Study of salt resistance in certain species	5 years	15 000
	Sub-total	75 000

Budget: in US dollars, rough estimate, phases 1, 2 and 3

Phase 1			
Personnel:	Consultants:		
	soil scientist, forester: 9 months	90 000[1]	
	Casual assistance	3 000	
	Coordinator: 1 month	7 000	
	Travel inside and outside the country	25 000	
	Soil sample analysis	2 000	
	Purchase of documents, misc. supplies, equipment rental	5 000	
	Secretarial assistance and communication (telex, telephone, mail)	1 000	
	Support to national research institutions for drafting of technical data sheets (to be shared according to the sheets produced)	50 000	
	Sub-total, phase 1:		183 000
Phase 2	Technical data sheets summing up knowledge:		
Personnel:	Consultants:		
	soil scientist, forester: 4 months	40 000[1]	
	Coordinator: 1 month	7 000	
	Secretarial assistance and communication (telex, telephone, mail)	1 500	
	Publishing and distribution	6 000	54 500
	Popular manuals		
Personnel:	Recent forestry graduate, communications specialist: 3 months	20 000	

---

[1] Costs including salaries, daily subsistance allowances and miscellaneous costs.

Budget: in US dollars, rough estimate, phases 1, 2 and 3 (cont'd)

	Illustrator: 3 months	10 500	
	Coordinator: 0.5 months	3 500	
	Secretarial assistance and communication (telex, telephone, mail)	1 500	
	Publishing and distribution	8 000	43 500
		Sub-total, phase 2:	98 000
Phase 3			
Personnel:	Consultant: 1.5 month	15 000[1]	
	Student or recent graduate: 2 months	5 000	
	Coordinator: 0.5 month	3 500	
	Secretarial assistance and communications (telex, telephone, mail)	500	
	Publishing and distribution of project documents	2 500	
	Miscellaneous	500	
		Sub-total, phase 3:	27 000

---

[1] Costs including salaries, daily subsistance allowances and miscellaneous costs.

PROJECT NO. 7

Title of Project

DEVELOPMENT OF A SITE DESCRIPTION METHOD

Justification

Paras. 311 and 312.

Objectives

To prepare a standardized method based on the analysis of certain environment-related parameters in order to appraise the reforestation potential of sites and to obtain data for site comparisons.

Duration

- 9 months for specialists in various fields (soil science, agroclimatology, forestry) and 9 months for coordinators of the three phases.

- 5 years for phase 2.

Organization(s) Proposed

- Coordinators and consultants - to be specified.

- To carry out phase 2 - development projects supported by national research centres

Activities

Project in three phases

Phase 1: Theoretical approach and preliminary data collection

- To establish a list of parameters that may be important to the description of a plantation site. The study should be conducted as investigations supplemented by detailed analyses (water balance, observation of root systems, study of wilt resistance, etc.)

  - Development of a questionnaire with the assistance of specialists
  - Distribution of questionnaire to various organisms operating plantations
  - Technical support in the form of an expert mission to collect base data (response to questionnaires and conduct of ecophysiological studies)

- From the data collected, to develop the first version of a site description method: selection of determining characteristics, hierarchical arrangement of parameters, development of simple methods of quantification and possibly of weighting parameters.

Phase 2: Testing of the method through a network of observation areas - case study

- To select a varied range of sites, to describe these sites according to the method and to choose sites for planting

- To check the reliability of the method (diagnosis of the capability of the site to be planted, recommendation on the species to use).
  - To establish a network of observation areas, in cooperation with development projects and with the support of local research centres (about 50 ha of plantations spread over some 20 different sites)
  - To monitor observation areas for 5 years
  - To study and interpret the results

Phase 3: Assessment and final adjustment of the method

- To publish the major results and the relationships made evident between site parameters and silvicultural performance
- To adjust the method as necessary to make it usable in the highest possible number of sites
- To define the limits within which the method is valid
- To prepare "Instructions for use".

Budget in US dollars, rough estimate

Phase 1

Personnel:	Consultants:	
	soil scientist, agroclimatologist, forester, physiologist: 12 months	120 000[1]
	Coordinator: 3 months	21 000
	Casual assistance	4 000
	Secretarial assistance and communication (telex, telephone, mail)	5 000
	Purchase of documents, equipment rental, miscellaneous expenses	10 000
	Travel inside and outside the country	40 000
	Sample analysis	5 000
	Rental of scientific equipment	5 000

1/ Costs including salaries, daily subsistance allowances and miscellaneous costs.

Budget in US dollars, rough estimate (cont'd)

	Data handling (by computer)	10 000	
	Publication of report	5 000	
	Subtotal, phase 1:		225 000
Phase 2	- To support agencies responsible for setting up and monitoring the observation areas (over 5 years)	200 000	
Personnel:	Coordinator: 1 mo/yr over 5 years	35 000	
	Consultants: soil scientist, forester, physiologist: 5 months over 5 year	50 000[1]	
	Travel inside and outside the country	25 000	
	Sample analysis	5 000	
	Purchase of misc. supplies, equipment rental	20 000	
	Rental of scientific equipment	10 000	
	Data handling (by computer)	15 000	
	Publication of reports	5 000	
	Secretarial assistance and communication (telex, telephone, mail)	5 000	
	Subtotal, phase 2:		370 000
Phase 3			
Personnel:	Consultants: soil scientist, agroclimatologist, forester: 2 months	20 000[1]	
	Coordinator: 1 month	7 000	
	Secretarial assistance and communication (telex, telephone, mail)	1 000	
	Publishing and distribution	7 000	
	Sub-total, phase 3:		35 000
	Grand Total		630 000

---

[1] Cost including salaries, daily subsistance allowances, and miscellaneous costs.

PROJECT NO. 8

Title of Project

HARDENING UNDER SAHELIAN CONDITIONS OF GUM ACACIAS PROPAGATED BY TISSUE CULTURE

Justification

Para. 313 and Appendix II

Objective

To develop hardening techniques under Sahelian conditions for young gum plants grown in sterile environments. The tissue culture propagated plants are akin to A. senegal clones selected for their high gum arabic yield

Duration

3 years

Organization Proposed for Implementation

Research project on gum trees - Kayes region, Mali. This project is financed by the "Fond d'aide et de coopération français" and is scheduled to start in 1986. It includes six research components:

1) Phenological studies and observation of the gum exudation phenomenon under natural conditions.

2) Study of biochemical and histo-cytological mechanisms of gum formation (study made jointly with three French basic research laboratories (see Appendix II).

3) Survey of gum tree plantations and study of social and economic gum harvesting contexts.

4) Genetic improvement of the gum tree (research carried out jointly with the AIDGUM foundation and the University of Aix-Marseille, France).

5) Improvement of tapping techniques.

6) Gum tree silviculture.

The research work proposed is within the framework of item 4).

Activities

The plants might be grown initially at the Aix-Marseille University but later by the Dakar "Centre des biotechnologies". From their arrival at the hardening unit to actual planting they still require three steps to be fully classified:

- removal of the plants from their containers
- transfer to a wet air-conditioned greenhouse
- gradual moisture decreases so that the seedlings adapt to normal outside air moisture levels

This unit is planned to harden 40 000 gum trees over three years.

Budget in thousands of CFA francs (estimate)

		Year 1	Year 2	Year 3	Total
Equipment:	100^2 greenhouse with double glazing	2 500			2 500
	Air conditioner, humidifier, watering system	8 000			8 000
	Tripod sprinkler	500			500
	Liquid fertilizer dispenser	300			300
	Insecticide spraying device	300			300
	Water supply pump	500			500
	Emergency power plant	2 500			2 500
	55% shading canvas	800			800
	Gardening equipment	300	150	150	600
Supplies:	Plastic bags (40 000 for three years)	200	200	200	600
	Vermiculite perlite	400	400	400	1 200
	Liquid fertilizer, insecticide, miscellaneous	50	50	50	150
Personnel:	1 Foreman and 2 labourers	1 000	1 000	1 000	3 000
Operational expenses:	Electric power, water	3 000	3 000	3 000	9 000
Editing and distribution of reports				2 000	2 000
TOTAL in thousands of CFA Francs		20 350	4 800	6 800	31 950
TOTAL in US dollars		50 900	12 000	17 000	79 900

- Mali's contribution: Provision of land
- Contribution from the gum tree research project: - time to be worked by specialists
  - overall project logistics

DOCUMENTATION AND RESEARCH CONSULTED

AID 1984 - Expérience acquise par l'AID dans le secteur forestier sahélien - Les possibilités futures - T.M. CATTERSON

C. BAILLY, C. BARBIER, J. CLEMENT, J.P. GOUDET, O. HAMEL 1982 - Les problèmes de la satisfaction des besoins en bois en Afrique tropicale sèche - connaissances et incertitudes - Bois et Forêts des Tropiques n° 197

Y. BIROT, J. GALABERT 1969-70 - Économie de l'eau et travail du sol dans les plantations forestières de zone sèche - application à la zone sahélo-soudanaise - Bois et Forêts des Tropiques n° 127 à 130

R. CATINOT 1984 - En Afrique francophone l'avenir forestier tropical se jouera dans le cadre du monde rural - Bois et Forêts des Tropiques n° 263

CILSS - club du sahel 1982 - Politique forestière au sahel - contraintes - coûts organisation par J. MOREL, J. PAJOR

CILSS - club du sahel 1981-1982 - Analyses du secteur forestier et propositions

- Le Cap Vert - H. SOARES, A. SABINO, P. MONTEIRO, O. FUGALLI, P. LABAN, J. PARE
- La Haute Volta
- Le Mali - L. COULIBALY, R. CATINOT, O. FUGALLI, J. MOREL, N. SANOGHO, S. KANOUTE, B. DIALLO, A. KANOUTE
- La Mauritanie - O. FUGALLI, H. Amadou KANE, M. Ould ABBY, D. DEIDY
- Le Niger - I. NAJADA, R. CATINOT, M. GOUNDAKOYE, L. COULIBALY, M. KEITA, C. FREUD, R. BELLEFONTAINE

CILSS - club du sahel 1983 - Le développement de la silviculture et de l'écologie au sahel - bilan et perspectives

CILSS - club du sahel 1983 - Le bois de chauffe: principale source d'énergie dans le sahel et les besoins en recherche

CILSS - club du sahel 1983 - Écologie forestière - synthèse des analyses nationales

CILSS - club du sahel 1985 - Synthèsee du séminaire régional sur la désertification au sahel - Nouakchott 29 octobre - 4 novembre 1984 - R.M. ROCHETTE

CILSS 1982 - Quantification des besoins en bois des pays sahéliens: une analyse des bilans-programmes - Équipe régionale Écologie-Forêts - Réunion de BANJUL 18 - 22 Octobre 1982

C.T.F.T. 1984 - Projet de recherche sur les gommiers pour une relance de la production de gomme végétale au Mali - C. COSSALTER, J. VASSAL

C.T.F.T. 1983 - Aspects de la foresterie villageoise dans l'ouest et le nord Cameroun D. DEPOMMIER

C.T.F.T. 1985 - Vulnérabilité de l'arbre en Afrique tropicale - J.P. GOUDET

C.T.F.T. 1985 - L'arbre et les formations ligneuses en Afrique tropicale sèche - J.P. GOUDET

C.T.F.T. 1985 - Étude sur la contribution de la recherche scientifique au développement forestier dans les zones arides et humides tropicales - besoins et priorités - F. GRISON, R. CATINOT

C.T.F.T. 1985 - Note sur les plantations forestières irriguées dans la vallée du fleuve SENEGAL - expérience de Podor (Sénégal) J.M. HARMAND

C.T.F.T. 1985 - Foresterie rurale IIème région au Mali - Amélioration du matériel végétal et des techniques silvicoles - les pare-feu arborés - M. MALAGNOUX

J.C. DELWAULLE 1978-1979 - Plantations forestières en Afrique tropicale sèche - Techniques et espèces à utiliser - Bois et Forêts des Tropiques n° 181 à 188

FAO 1981 - cahier technique n° 3 - Liste mondiale des écoles forestières

FAO 1979 - cahier technique n° 8 - Technique de plantation forestière

FAO 1981 - cahier technique n° 11 - Boisement des savanes en Afrique

FAO 1984 - cahier technique n° 48 - Land evaluation for Forestry

FAO 1982 - Les disponibilités de bois de feu en région sahélienne de l'Afrique occidentale - situations et perspectives - M.N. KEITA

FAO 1984 - Études hydrologiques et pédologiques - Cap Vert - Ch. M. MANNAERTS

FAO 1985 - Rapport sommaire sur la consultation d'experts sur le rôle de la foresterie dans la lutte contre la désertification - Saltillo (Mexique) 24 - 28 Juin 1985

INRAN 1981 - Les essais d'introduction et de silviculture de l'Eucalyptus en sec au Niger - D. LOUPPE

ISRA/CNRF 1984 - Expérimentations sur les plantations forestières irriguées dans la vallée du fleuve SENEGAL

B. JEAN 1985 - Sécheresse et désertification au Mali - Situation actuelle et perspectives - Revue Forestière Française n° 2 et 3 - 1985

LABORATOIRE DE CHIMIE DU MUSEUM D'HISTOIRE NATURELLE 1985 - L'acide usnique, un inhibiteur de transpiration stomatique d'origine naturelle - O. MOLHO, E. BATCHO, J. CARBONNIER, H. CHAKER

MINISTÈRE DE L'ENVIRONNEMENT ET DU TOURISME 1983 - Méthodologie d'évaluation des terres appliquée à l'aménagement forestier en Haute-Volta - A. CAMPAORE, P. LABAN, O. ZIDA

MINISTÈRE DE LA COOPÉRATION 1979 - Conservation des sols au sud du sahara - C.T.F.T.

PROJET FORESTIER NIGER 1985 - Production ligneuse en irrigué dans les périmètres aménagés du Sahel nigérien et sénégalais - O. HAMEL

SAVANNA FORESTRY RESEARCH STATION 1973 - Provenance trials and Eucalyptus camaldulensis in the savanna region of Nigeria - J.K. JACKSON

SAVANNA FORESTRY RESEARCH STATION 1974 - Silviculture and mensuration - J.K. JACKSON

SAVANNA FORESTRY RESEARCH STATION 1984 - Plantability of forest reserves in Nigerian savannas - M.I.S. EZENWA

H.J. VON MAYDELL 1983 - Arbres et arbustes du Sahel - Leurs caractéristiques et leurs utilisations.

APPENDIX I

Extract from: "Land evaluation for forestry - FAO Forestry Paper 48"

Table 7.1. Land qualities for forestry, with land characteristics which may be used to measure or estimate the qualities. Characteristics which follow a colon provide indirect estimates.

LAND QUALITY	LAND CHARACTERISTICS
A. Qualities affecting growth	
1. Radiation regime	Total radiation, sunshine hours, aspect; day length: latitude, climatic type
2. Temperature regime	Temperature - mean annual, mean for growing season, hottest, coldest months: altitude, aspect, climatic type
3. Moisture availability	Relative evapotranspiration deficit, rainfall/evaporation ratio, depth to groundwater; rainfall - mean for growing season, mean annual: aspect, vegetation indicators
4. Soil drainage	Soil drainage class, depth to mottling: vegetation indicators (communities or species)
5. Nutrient availability	Mean levels of N, P, K, etc., soil pH: topsoil thickness, soil type
6. Rooting conditions	Effective soil depth, stones and gravel, rock outcrops and boulders, soil structure: soil type
7. Conditions affecting germination and establishment	Soil texture, stones and gravel, surface sealing or capping
8. Salinity/sodicity	Electrical conductivity of saturation extract, exchangeable sodium percentage: soil type, vegetation indicators
9. Other toxicities	Observed toxicities, soil pH: soil type
10. Climatic hazards - fire	Observed frequency; length of dry season, rainfall/evaporation ratio, combustibility of ground vegetation
- frost	Mean frost days: altitude
- wind	Frequency/severity of high winds, typhoons; exposure index, aspect

LAND QUALITY	LAND CHARACTERISTICS
11. Physiographic hazards - flood	Observed frequency/severity: topographic site
- landslide	Observed frequency/severity: slope angle, rainfall intensity, soil depth
12. Incidence of pests and disease	Observed incidence; relative humidity, temperature, soil factors of known influence
B. Estimates of forest volume, growth and yield	
13. Present timber volume	By species, from forest inventory
14. Predicted timber yield	By species, from forest yield prediction or growth-site correlation: site index
15. Seedling survival rates	Recorded averages for site types or area as a whole, by species
16. Predicted yield of non-timber products	From forest inventory or prediction
C. Qualities affecting management	
17. Terrain factors affecting mechanized operations and internal access	Terrain class; slope angle, relative relief, stream frequency, microrelief, bearing capacity, presence of swamps, cracking clays.
18. Conditions affecting nursery sites	Available water supply (surface or ground water), soil texture
19. Present vegetation cover	Ease of clearance
20. Size of potential management units	Size of blocks of suitable land
21. Location	Distances from earth road, tar road, rail or river; and from sawmills or other marked
D. Qualities affecting conservation	
22. Erosion hazard	Estimated soil loss, t/ha/year; slope and rainfall erosivity, soil erodibility, rainfall intensity, soil permeability, soil texture, vegetation cover: soil type
23. Water yield	Recorded or estimated

LAND QUALITY	LAND CHARACTERISTICS
24. Predicted response of steamflow	Hydrological modelling
25. Tolerance to vegetation degradation	Observed or estimated; present condition of vegetation, vegetation type
26. Presence of valuable plant and animal species	Presence, rarity
E. Qualities affecting recreation potential	
27. Scenery	Aesthetic or scientific value, and variety of landlands and vegetation
28. Resources for recreational and tourist activities	E.g. rock climbs, fishing resources
See also Qualities 10 (fire hazard), 20, 21, 22, 25, 26	

APPENDIX II

THE FUTURE OF GUM PLANTATIONS IN THE SAHEL

Vegetable gum, which has numerous applications in the food, pharmaceutical, cosmetic and chemical industries is at present the only forest product exported by the Sahel. Among the various kinds of gum only gum arabic and Sterculia setigera and Combretum spp. gum are now marketed. Gum arabic is the most interesting in economic terms. The term gum arabic refers to two kinds of gum:

- hard gum, which is more in demand for its quality, is produced above all by Acacia senegal and Acacia laeta. The second species is relatively frequent in Western Africa. Other Acacia species, of which the gum-producing potential is still to be determined, produce a gum of the same kind. They are Acacia mellifera, A. gourmaensis, A. polyacantha ssp. campylacantha:

- brittle gum, which is produced essentially by A. seyal. The same kind of gum is produced by: A. ehrenbergiana, A. nilotica ssp. adstringens A. tortilis, A. sieberana var. sieberana.

There are several research and development programmes in progress on gum and gum-trees in, or in cooperation with, Western African countries:

- genetic selection and improvement of gum-trees - CNRF test centre of Mbiddi in Senegal and a planned unit in Mali in the Kayes region

- tissue culture propagation of gum-trees and particularly of Acacia senegal - AIDGUM [1] and Aix-Marseille University, France

- selection of gum-trees as a function of their nitrogen-fixing capacity, and study of symbiotic associations - ORSTOM Senegal

- histo-cytological patterns of gommosis, Toulouse University, France

- physiological patterns of gommosis, and tissue cultures of gum-producing Acacias - CNRS, St Martin d'Heres, France

- macromolecular properties of gum - CNRS, Mt St Aignan, France

- development of production systems combining A. senegal with crops, within the framework of development projects; particularly in Senegal and Mauritania.

The IRANEX Company, the world leader in gum marketing and processing, is very much involved in several of these programmes or projects.

The progress made with A. senegal as regards selection, cloning in tissue cultures, and symbiotic association indicates that soon very productive clones mutiplied on a large scale might be made available for development programmes.

1/ International Association for Vegetable Gum Development, created by the IRANEX Company

Currently tested individuals produce 5 to 7 kg of gum per year, whereas the average yield is only 0.8 kg.

Such technical progress might change the current supply system, based on gathering in natural stands, a practice that is declining throughout Western Africa because of the drought, which kills the gum stands and causes populations to leave.

If A. senegal is given much greater economic value [1] it becomes possible to develop individual plantations combined with crops (as is the practice in the Sudan: bush fallow system; and in Senegal on much smaller scale), or even large-scale cultivation (as is the case in the Sudan).

A similar development pattern, combining the industrial sector, local marketing circuits, rural populations, research and development structures - both local and in industrialized nations - might be contemplated for tannin which plays a considerable part in the Sahel in view of the importance of animal husbandry. The official forestry agencies of Nigeria are planting A. nilotica adstringens in the north of the country for the purposes of supplies to local tanning plants.

1/ Present producer prices for gum arabic range from 400 to 500 F.CFA/kg.

NURSERY AND FUELWOOD PLANTATION PRACTICES IN ARID AND SEMIARID ZONES OF NORTH-EAST AFRICA

F.B. Armitage and J. Burley

Oxford Forestry Institute
Oxford University
South Parks Road
Oxford, England

TABLE OF CONTENTS

Page

Introduction 264

A. Development objective 265

B. Immediate objectives 265

C. Special considerations 265

D. Background and justification 266

E. Outputs 269

F. Activities 270

G. Inputs 271

H. Preparation of project document, work plan and budgets 272

I. Preparation of framework for effective participation of national and donor agency staff in the project 273

J. Development support communication 273

K. Institutional framework 273

L. Prior obligations and prerequisites 274

M. Future donor assistance 274

N. Monitoring, evaluation and reporting 274

O. Check list of potential research topics 274

P. Acknowledgements 276

References 277

INTRODUCTION

The International Union of Forestry Research Organizations (IUFRO) with the support of the World Bank, UNDP, FAO, and several bilateral donor agencies, is convening a series of regional meetings in Asia, Africa and Latin America to encourage the participation of aid agencies and forest research organizations in the developed world to support and, as appropriate, participate in, the strengthening or inflation of forest research in developing countries. The meeting for Asia was held in Kandy, Sri Lanka, in June, 1984. The second will be held in Nairobi in January, 1986, and will focus on research requirements for plantation (particularly energy plantation) development in countries of the Sahelian, Sahelian-Sudanian, and Sudanian zones of north east, north central, and north west Africa. Documentation for the meeting will comprise a series of papers addressed to segments of the development topic as it relates to the ecological zone mentioned in (a) north east and (b) north west Africa. To facilitate the selection of prospective project topics and subsequent project preparation and planning by prospective aid agencies, the papers are to follow the UNDP project document format. This paper presents available information and outline proposals for nursery, plantation establishment, and plantation management research in the five north east African countries Kenya, Tanzania, Sudan, Somalia and Ethiopia. Djibouti is also listed although no information is available for it.

The arid and semi-arid Sahelian and adjacant Sahelian-Sudanian and Sudanian zones, are characterized by harsh climates with variable, low rainfall and soils that are mostly poor, with low humus content and moisture retention capacity. As a result of increased pressures to meet the needs of humans and animals, the plant and soil resources are subject to serious depletion. Over increasingly wide areas this has led to desertification. Among the countries of which appreciable areas are subject to these conditions are Kenya, Tanzania, Sudan, Somalia and Ethiopia, to which this paper relates. (No information was available for Djibouti.)

Effective corrective measures necessitate re-vegetation by the several means available, including the establishment of tree plantations of various forms involving the full participation of local communities, individual actions being determined on the basis of the ratio of actual populations to the carrying capacity in each given area. Such tree establishment programmes, where they exist in the countries listed, are small in relation to the scale of the needs. Without exception they are subjet to constraints, not simply of lack of money and equipment to enable the work to be done, but also of inadequate institutional development and staff training, lack of the needed appropriate technologies (adaptation of existing technologies for local use) and extension services to convey them to the operational front and of monitoring and evaluation so necessary for planning and further technological development.

No significant change is possible without both radical improvements in these factors and technological changes applied through trained, vitalized and motivated institutions and the participation of communities interested, empowered and prepared to make available their lands in a sustained manner for the planting programme required. The new or improved technologies can come only from strong technical and related socio-economic research programmes (which do not exist in the countries listed) in relation to the planning and operational areas concerned. Among these are nursery production and plantation establishment and management.

The proposals that follow are common, with modifications in detail in each case, to each of the countries concerned. They are based on conditions and needs in those countries, for each of which a "country profile" is being developed as a separate document. This paper, which follows the UNDP project format, and the supporting appendices, has been prepared on the basis of the documentation available, which is less comprehensive for some of the countries than the others, and in which there are regrettable but unavoidable gaps. As it has not been possible to undertake analyses in the field, this paper is perforce the outcome of a desk study.

It is intended that prospective donor agencies, in collaboration with appropriate representatives of the countries they choose to assist, would use this paper as a guideline for the preparation of specific research project documents and plans. It is not feasible to prepare a normally detailed and costed project to cover the five or six countries because of the widely differing conditions and the likelihood that different donor agencies would be interested in different, single countries. Further any project concerned with fuelwood production must be integrated with agroforestry and tree improvement activities described in other papers at the workshop.

A. DEVELOPMENT OBJECTIVE

The research and related programme proposed would produce needed support in the form of technically and socio-economically resilient methods for the large-scale developments in fuelwood production, watershed and soil conservation, environmental amelioration and other products, services and benefits needed (and in several cases already in their initial stages) in the countries concerned.

B. IMMEDIATE OBJECTIVES

The immediate objectives would be:

(a) to develop nursery production and plantation establishment and management systems and technologies for rainfed and irrigated tree plantations of various kinds,
(b) whilst ensuring that such systems would conform with socio-economic conditions in the areas concerned, to indicate where changes should be made in the interests of successful tree plantation and management,
(c) to establish institutional capability in all phases of nursery and plantation research based on soundly trained, equipped, motivated and managed research personnel,
(d) to contribute to the establishment of strong institutional capability in planning, conducting, monitoring, evaluating and upgrading nursery production and tree plantation and management programmes, and
(e) to contribute to the establishment of effective extension services, equipped with the information and aids required for their function.

C. SPECIAL CONSIDERATIONS

Existing multi- and bi-laterally supported programmes in progress in one or more of the countries to which this paper relates are focussed on

(i) anti-desertification and amelioration of the environment in general,
(ii) rehabilitation of watersheds and soil and water conservation,

(iii) establishment of plantations for the supply of fuelwood, poles, fodder, shelter and shade,
(iv) food production to alleviate shortages, particularly in drought years, and enhancing economic results of farming by providing additional sources of cash,
(v) mobilization and involvement of the people in programmes to these ends,
(vi) strengthening of institutional planning, research and operational capabilities, and
(vii) establishment of mechanisms for research coordination and cooperation within and between countries.

The project would pursue these goals through the development, demonstration and dissemination of technologies for nursery production and plantation establishment and management required directly for items (i) to (iv) above. The integration of tree planting with other development activities, e.g. rural development, watershed rehabilitation, environmental amelioration or land reclamation, would be emphasized where appropriate. Item (v) would be met firstly through the appropriateness of the technologies to be developed for use by farmers in systems applicable to their operations, and secondly through the conformity of the technical packages to be produced with prevailing socio-economic conditions, together with recommendations for modification of the latter where this is desirable, e.g. in respect of tenure and ownership of trees. Too many tree planting projects have failed because of single-minded attention to biological technology in isolation from dominantly important socio-economic factors.

Item (vi) would be met through the provision of training, both in-service, on-the-job under the guidance of technical specialists, and outside the country. Strategies to be developed to motivate research personnel and others concerned, would include methods of achieving peer, community and other recognition of success. In this and other ways the institutional capabilities to be built or strengthened would be strongly oriented to development objectives and goals.

Item (vii) would be addressed through twinning arrangements with similar, established institutions in either developed or developing countries, leading to the development, at the appropriate stage, of networking among researchers working in similar, relatively narrow, subject areas, as well as by supporting and furthering the CDA approach.

Wherever possible the needed research capabilities to support nursery production and dry zone plantation technology would be strengthened within existing institutions. Only where none pre-exists should the creation of a new one be attempted. Whilst development of the specific research capabilities to which this paper is addressed could be a component of a wider project, e.g. fuelwood production, watershed rehabilitation, or rural development, care should be taken to ensure that a strong central forest research organization is fostered. Developing countries are not usually benefitted by the balkanisation of such institutions.

D. BACKGROUND AND JUSTIFICATION

(i) Background

Tree, shrub and other vegetation in the dry lands is subject to widespread degeneration with resultant desertification, a process of sustained decline of productive capacity due to over-cutting, grazing, browsing and, in riverine areas, cultivation, combined with the effects of periodic severe droughts. Depletion of the plant cover has resulted in critical shortages of wood (particularly fuelwood) and fodder, erosion of soil, degradation of watersheds, and depleted shelter and shade. These conditions are particularly marked in the vicinities of concentrations of population (BOSTID, 1983a; Brookman-Amissah, 1984; FAO, 1984b; World Bank, 1984).

The governments concerned fully recognize the critical condition of the dry lands, which are the habitat of relatively large human populations, including nomads. With the support of aid agencies, they have formulated proposals and, over the past 20 or more years, initiated measures to ameliorate the situation in various ways, including reforestation in several forms. With few exceptions (irrigated plantations in parts of Sudan form one) these efforts have been frustrated by lack of trained manpower, including planning, managerial and research capability, ineffective nursery production and plantation establishment and management technologies, lack of maintenance and protection of areas that have been planted (partly as a result of a sociological environment that is hostile to growing trees), inadequacy of capital and operating budgets, equipment and facilities of every kind. The size of budgets, particularly for research, has actually declined in some cases recently. Forestry extension services are usually inadequate. The standards achieved in field operations are often low. With reference to nursery production in both developed and developing countries, a veteran USA silviculturist is credited with the statement that "In the average nursery we are still raising genetic garbage" (Anam, 1981; Booth, 1985; Brookman-Amissah, 1984; FAO, 1984c; KMENR and USAID, 1984; USAID Bureau for Africa, 1984; World Resources Institute, 1985; J.A. Odera, Kenya Agricultural Research Institute, personal communication, July 1985.)

Research topics necessary for the solution of the problems of natural resources in dry lands virtually suggest themselves. In respect of nursery production and plantation establishment and research, they would be to develop technical nursery production packages that would enable nurseries operated by government, NGO or local community to produce high quality stock of specifications suited to the environmental and operational conditions that obtain. Technological packages are also needed for planning, establishing and managing fast growing plantations of various kinds, including the manipulation of sites for harvesting and conservation of such rain as falls, together with proposals for sociological changes and development of the requisite extension and technology demonstration materials. Both nursery and field packages should include monitoring and evaluation methods that would provide essential feedback for operational planning and management and further research inputs. Institutional capabilities for research, planning, management and operation would require development to enable all the forefoing to happen. Equipment and other facilities would be required to enable the work to proceed. Arrangements would be made for the work and results to be shared, to mutual advantage, by researchers and research institutions within and between the countries concerned (Booth, 1985; Burley and von Carlowitz, 1984; Bryce, 1974; FAO, 1984d; Gosh, 1977; Hotte, 1984; Kaul, 1970; KMENR and USAID, 1983; J. Seyler, USAID/REDSO/ESA, Nairobi, personal communication, May 1985; USAID Bureau for Africa, 1984; World Bank, 1984; Wormald, 1984.)

(ii) Justification

Without the inputs of money, training, technical assistance, equipment and other facilities that the project would provide, it would not be possible to mount the research programme required to produce the needed technological packages. In the absence of the latter - in spite of whatever other inputs that there might be - effective seedling production and field planting and tree management programmes would not materialize; past and even some current efforts testify to that. Research outputs are not all that would be required, but without them, and without the right kind of motivation in all phases, there would be no worthwhile, lasting accomplishments of resource development.

Throughout the dry lands in the region people and their stock have sunk to a low level of subsistence due to the natural events and man-made influences referred to above. The community of multi- and bi-lateral aid agencies is fully aware of the needs. Their presence in the countries concerned in large numbers (see KMENR and USAID, 1984, and the documents placed before the CDA meeting at CFI, Oxford in May, 1985) testify to their willingness to play their part in mending the damage that has been done. Large World Bank projects have either been initiated or are mooted for restoration of the vegetative cover, fuelwood producton or watershed rehabilitation in the area; the World Resources Institute (1985) refers to one project recently initiated in Ethiopia as "the largest watershed rehabilitation project in the world". This Institute makes specific recommendations as to levels of investments required into fuelwood and agroforestry plantation development (including nursery and plantation systems development and other relevant research and training) in Africa during the 5 years 1987-91. The total sums suggested for the countries with which this paper is concerned are:

	US$ millions
Ethiopia	40
Kenya	48
Somalia	15
Sudan	35
Tanzania	30

The Institute proposes that ten percent of these sums should be used for research. A substantial part would be devoted to the dry lands. (Additional sums are proposed for land use, including watershed rehabilitation on upland watersheds, most of which are humid.)

It must be stressed that without the improved, field tested technologies it is certain that all the efforts and investments mentioned in the previous paragraph would achieve very little. Availability of improved technologies of the kind proposed is a prerequisite for effective operational programmes.

The country profile documents indicate what research, if any, is in progress in relation to nursery production and dry land plantation systems, what agencies undertake it and how effective it is. In no instance is adequacy of such programmes even approached. Also indicated are the inputs by bi- and multilateral agencies.

E. OUTPUTS*

Within five years the project would have prioritized the research needs for nursery production, plantations establishment and plantations management for the dry lands; initiated the adaptation to local conditions of technologies developed elsewhere; reviewed relevant literature and operational programmes and their results; established and begun the assessment of site-specific tests and demonstrations under key representative conditions; identified important technological gaps and initiated research to make them good. It would have begun to disseminate and transfer technical information that would increase the success, growth rates and productivity of irrigated and rainfed tree plantings in on-farm blocks, inter-croppings, and shelterbelts using a selected core of multipurpose tree species, including indigenous ones. The technical packages would include nursery establishment and tending techniques in relation to indicated specifications for the improved materials to be produced; rainfed and, where appropriate, irrigated plantation systems covering site evaluation and problem identification, intensive site preparation, rainfall harvesting, establishment and early tending techniques; management systems embracing spacing, thinning and rotations, foliage manipulation (coppicing, pollarding, lopping) and species mixtures; harvesting methods that promote maximum production in the succeeding crop; pest management and control; protection from animals and fire; sociological and economic aspects; monitoring and evaluation. It would have begun the production of crop volume and outturn tables giving assortments of total biomass after the style of, for example, Shetty (1984).

Further, the project will have contributed to the establishment of an extension service through preparation and publication of research materials, participation in the training of extension personnel and preparation of extension materials.

A research institution comprising a group of professionals capable of identifying constraints to land use and forestry operations, and of conducting a programme of the above nature, will have been established, under a small, competent, trained research management team. Programme management and documentation and editorial and publication procedures would be in place, as would necessary (but not superfluous) support staff, library services and equipment.

Working relationships, including those for monitoring operational technologies, will have been established with appropriate resource management agencies and individuals and with universities and NGO's engaged in forestry-related research. A start will have been made to develop networks with research personnel working on similar problems in other countries in the region.

The research institutions to be developed, supported or strengthened would be approaching the stage at which they could begin to operate efficiently and effectively without the advice and other assistance of technical specialists.

---

* Choice of species, genetic improvement and provision of seed are excluded since they are being covered in another paper.

F. ACTIVITIES

The research programme would be developed with the emphasis on applied, mission orientated approaches. To this end the research officers would work in small multidisciplinary task forces on specific, identified problems or opportunities. The research would focus on drought resistant, high yielding species, genetic materials and technologies adapted to local situations, including prevailing socio-economic factors (which would require analysis).

Each identified research problem or opportunity would be addressed by a research *project* (the team effort) with a team leader and comprising a series of component *studies*, each the contribution of one member of the team. For the project as a whole and for each study there would be a written plan with defined objectives, to be achieved within an estimated time span, and realistic annual goals. A research officer could be a member of more than one team. Once the defined objectives of a research project (as defined here) have been achieved, it would be closed, subjet to arrangements being in place for monitoring the operational applications of the technology developed. The research officers thus released from a terminated project would then be available to work on other priority problems or opportunities.

To strengthen the linkages between research and operational programmes, a team would normally include a research development officer - a person with good forestry operational experience and some bent for research. He would usually participate in several research projects, being responsible for the field test sites and demonstrations and liaison with operations personnel. He would also play an important part in activities such as the production of extension materials.

Since resources for research are certain to be limited for an indefinite time, priorities would be carefully selected and sharply defined, if possible with the aid of economic analysis and using methods and measures such as those described by G R Armstrong (in KMENR and USAID, 1984). Research on a topic would begin with review and analysis of the current state of the art, pertinent literature, key developments and research in the past. This phase would usually involve some inspection and analysis of situations in the field.

It is of the utmost importance that these prerequisites for efficient research be respected. Some of the key references to the literature are included in Appendices 1-6 and therefore also in the list of references included in this paper. Other, pertinent papers, most of which embrace relevant bibliographies, include:

Species selection:	BOSTID (1980), (1983b) (1984b); FAO's Forest Resources Division's series "Forest Genetic Resources Information"; Burley and von Carlowitz (1983).
Agroforestry:	BOSTID (1984a); ICRAF's Working Papers and Reprints series.
High yielding plantations in dry lands:	Felker (1983), (1984); Klass *et al* (in press).
Irrigated plantations:	Armitage (1985); Hamel (1985).
Shelterbelts:	Bayoumi (1977); Bognettean-Verlinden (1980); Eimern, J. van *et al*. (1964); Saleem (1973).

Socio-economic aspects: Anderson and Fishwick (1984); BOSTID (1984a); ICRAF's Working Papers and Reprints series; Nocouha (1980).
Research networking: Burley (1984); Plucknett and Smith (1984).

Individual site specific studies would follow, beginning with tests and demonstrations of the seemingly most appropriate existing technologies and materials, followed by trials and experiments to fill identified gaps, make good weaknesses, or effect improvement. Testing would be done each time technologies or materials are modified as a result of such experimentation. There would be ample opportunities for innovation.

Each project would be subject to review by the participating research officers when they deem this to be necessary. Each project and its component studies would be subject to overall supervision by the management of the research centre, and to formal review, at least once a year, when each researcher would present his work for review in relation to overall programme priorities as well as to the strategies, objectives and goals of the research project and their component studies. The officer's peers in the project would participate. Again, review procedures and measures such as those discussed by Armstrong (loc. cit.) would be applicable.

Research officers would be required to publish the results of their research regularly and without undue delay, after appropriate editing. They would participate with the research development officers to formulate and establish demonstrations and produce written or other materials for extension purposes. They would participate in seminars, field days and the like, arranged for transfer of technology to users.

Small subject or problem oriented networks of research workers from different countries in the region would be developed to share information, research methods to be used and the tasks that have to be performed to solve common problems, stimulate programmes and maximize synergistic efforts. Development of research networks would begin once programme priorities have been identified and work commitments to them made in the separate countries e.g. when common interests or concerns among countries as well as potentially appropriate lead agencies are apparent (see Burley, 1984).

Training of research and research management personnel would be accomplished through in-service workshops, seminars, short courses and demonstrations initiated by technical specialists provided by donors, by short (1-2 months) study tours, transfers to appropriate research establishments in other countries, and by fellowships for formal undergraduate and postgraduate training to build up a core of fully qualified research personnel. The general area of training is particularly susceptible to benefits from twinning arrangements.

G. INPUTS

During the formulation phase of the assistance project (see H below) specific consideration would be given to the needs for the government to assign a research director to act as counterpart to the senior advisor provided by the project and counterpart as required and appropriate to any medium or short term consultants joining the project. Such advisers would require working facilities such as office accommodation, housing, and typing support. The government would normally provide research and support staff, labour and the costs and facilities involved in employing them.

At least in the initial stages of the project the donor agency would provide a senior research adviser to assist with the organization, management, staffing, training, equipment, programme formulation, structuring, development and procedures of the research institution. Medium term consultants would be needed for training, organizing the facilities and mounting the programmes of phases such as nursery development and production, plantation establishment and management. Short term consultants would be required to assist with economic and sociological studies relevant to these two components, including definition of priorities, technology transfer and the development of extension materials. To the extent that they are available, such consultants might be recruited locally.

The donor agency would normally provide, to the extent necessary, field, laboratory and office equipment, tools, materials (including seeds, fertilizers and the like), transport, library materials, training and related travel costs and infrastructural development. It must be recognized that different countries and different donor agencies have different rules regarding the foreign exchange and local currency elements of project expenditure.

H. PREPARATION OF PROJECT DOCUMENT, WORK PLAN AND BUDGETS

Before the establishment of strengthening of a forest research institution begins, the prospective donor agency would collaborate with appropriate representatives of the country to be assisted, to identify the nature, scope and priorities of the project and programme to be undertaken, the strategies and institutional arrangements to be developed. The technical assistance, training and physical inputs required to establish and sustain the institution and its programme would be identified. Those to be provided by the country and the donor respectively, and the general timing of such inputs, would be specified and mutually agreed.

Preparation and acceptance of the project document by the country and donor agency concerned would enable a detailed work plan for the implementation of the project to be prepared by the senior adviser assigned by the donor agency in consultation with the head of the research centre or (in his absence) of the government forestry agency. This will be done in outline 4-6 months before the start of the project to identify the need for preliminary actions and for them to be undertaken before the project begins. The plan would be up-dated at the beginning of the project and again at least annually thereafter. The agreed work plan would be attached to the project document as an annex.

Within three months from the beginning of the project the senior adviser, working with the director of the research centre (or in his absence, the head of the government forest authority) would produce a detailed plan for the whole project period. This would indicate the phasing of recruitment of technical advisers and consultants; recruitment and training of research, support and administrative staff; acquisition of transport, equipment, tools, materials and supplies; provision or improvement of infrastructural features; contacts with institutions to be consulted in respect of the research programme and its development; review of current status of nursery and plantation activities and research needs; planning the research; phased research development plan, including timing of inputs and outputs; monitoring and review of the programme; guidelines for setting up research networks.

Detailed annual and periodic budgets for the agreed research programme and project budgets would be prepared by the senior adviser on behalf of the donor agency in collaboration with the research institution director.

I. PREPARATION OF FRAMEWORK FOR EFFECTIVE PARTICIPATION OF NATIONAL AND INTERNATIONAL STAFF IN THE PROJECT

The activities necessary to produce the indicated outputs and achieve the project's immediate objective would be carried out jointly by the national and donor agency staffs. The respective roles of these staffs would be determined by their leaders, by mutual discussion and agreement, at the beginning of the project, and set out in a Framework for Effective Participation of National and International Staff in the Project. The Framework, which would be attached to the Project Document as an annex, would be reviewed from time to time.

J. DEVELOPMENT SUPPORT COMMUNICATION

It is pertinent to note here the value to participation of prospective donor agencies, international and national staffs of activities such as the CDA Process (USAID, 1985) and the research workshop documented in KMENR and USAID (1984). The informative, coordinating functions described dispel the confusion caused by the plethora of sectoral programmes that characterize some countries, obviating much duplication of effort and reducing confusion of the local people and their institutions.

The need to involve local communities in nursery production and tree plantations has already been mentioned. The Peasant Associations of Ethiopia are potentially a model in this area, of the utmost value to the resource management agencies. However, without careful study and structuring of linkages, their participation or that of farmers, chiefs and the like would not necessarily be automatic, assured or ideal in its nature and effectiveness. This aspect would require analysis and some sociological probing under the research programme. This need would be borne in mind by those preparing the project and its work programmes as they develop its technology transfer mechanisms and review research needs.

It would be borne in mind that communications between forest authorities and the rural people is usually best in countries where the former are decentralized (and therefore less effective in other ways), as in Ethiopia and Tanzania, or where tree planting forms part of rural development projects. It is often less ideal in countries where the forest authorities are not decentralized and their staffs tend not to communicate with the people, indeed where they are often regarded with suspicion by local people who see them in the role of policemen.

K. INSTITUTIONAL FRAMEWORK

Summary accounts of institutional arrangements and pertinent features of them will be given in the country profiles (in press). The countries vary considerably in these respects. They do not all currently have forest research institutions and there are institutional constraints in all of them to effective forest research as well as to the transfer of research outputs to the field. An institutional weakness that they all appear to have that would frustrate the continuity of research and forest development is the lack of a staff career structure. This applies to both research and operational field staffs (see Burley and Salleh, 1985).

Among the reasons for the priority that would be given to institutional development and strengthening is the fact that such activities are necessary if aid dollars and other inputs are to be used effectively.

L. PRIOR OBLIGATIONS AND PREREQUISITES

(i) Obligations

Where no forest research agency exists, the government of the country would undertake to provide the personnel, funding and physical resources, institutional setting and administrative support, and (if necessary) legislative or like instruments, as specified in the agreed project document, to enable one to be established. The same provisions would apply, to the extent needed, where existing institutions are to be strengthened and their programmes improved by the projects.

Governments would supply the project with information, including maps, concerning their forestry and related development programmes in the dry lands and intentions for their modification. They would permit project personnel access to field sites of such development programmes and allow local staff to participate in training and other activities of the project.

The donor agency would make timely arrangements to effect the project inputs it undertakes to provide.

(ii) Prerequisites

Where appropriate, the donor would expect the country to give due consideration to, and if possible to promote, the relaxation of constraints to tree plantation establishment, management, protection and harvesting caused by characteristics of land tenure, tree ownership, marketing arrangements and the like.

M. FUTURE DONOR ASSISTANCE

The donor would indicate, in the project document, the possibilities for extension of assistance beyond the project period.

N. MONITORING AND EVALUATION AND REPORTING

The project would be subject to periodic and terminal review, evaluation and reporting in accordance with the policies and procedures established by the donor for monitoring project and programme implementation.

Technical reviews of the research would be conducted at least annually as indicated in Section F: Activities.

O. CHECK LIST OF POTENTIAL RESEARCH TOPICS

In the World Bank and FAO (1981) review of forest research priorities in developing countries, Annex 4 listed in priority order the broad spectrum of research topics under the four main headings:

Forestry in relation to agriculture and rural development.
Forestry in relation to energy production and use.
Management and conservation of existing resources (mainly natural forests).
Industrial forestry.

Clearly the first two of these are of relevance to the present paper but the detailed research needs will vary between the countries in the region. The following checklist is provided to facilitate a review of current activities and needs in order to prepare any detailed project concerned principally with fuelwood; it should be read in conjunction with the World Bank and FAO (1981) report.

Sociological and institutional research
    Human perceptions of tree services and benefits.
    Knowledge of natural environments.
    Authorities and institutions.
    Land use, tenure, tree ownership.
    Incentives for tree planting.
    Economic returns and acceptability of
    - block plantations
    - single trees or lines of trees
    - shelterbelts
    - intercropping (agroforestry)
    - silvopasture.

Choice of species/provenance
    Exploration.
    Evaluation.
    Conservation.

Seed research
    Collection.
    Storage and testing.
    Germination.

Nursery research
    Sowing methods and seasons (and transplanting if necessary).
    Soil mixtures.
    Container type.
    Fertilizers.
    Irrigation.
    Shade.
    Physiological/physical quality of stock.

Plantation establishment
    Site mapping and selection.
    Site preparation methods.
    Planting techniques.
    Fertilizers.
    Irrigation.

- Plantation management and protection
  - Spacing.
  - Thinning.
  - Weeding.
  - Pruning, pollarding, coppicing.
  - Species mixtures including agroforestry.
  - Fertilizers.
  - Pests and diseases.
  - Fires and human interference.

- Basic rhizosphere studies
  - Nutrient cycling.
  - Nitrogen fixation.
  - Mycorrhizae.
  - Mulching.

- Tree improvement
  - Selection.
  - Genetic testing.
  - Seed production.
  - Clonal propagation.

- Basic economic studies
  - Product demand.
  - Harvesting.
  - Marketing and utilization.
  - Environmental impacts.

- Work study
  - Tools and machinery.
  - Ergonomics.
  - Safety.

In addition such a checklist should include for completeness:

Extension, training, provision of information.

- Programme management
  - Planning.
  - Responsibilities.
  - Monitoring.
  - Evaluation.

P. ACKNOWLEDGEMENTS

The authors acknowledge with much appreciation the assistance, in provision of basic documentation, of Mr. O. Fugalli, Coordinator of IUFRO's Special Program for Developing Countries, and of Ms Christel Palmberg, Chief of Forest Development, and Ms Franca Monte, Officer-in-Charge of the Forestry Library at FAO, Rome.

REFERENCES

Abdulcadir, Aden Mahamed (1975). Some studies on frankincense plants (Boswellia spp.). Degree thesis U. of Somalia, Mogadishu.

Anam, S.A. (1981). Technical notes and recommendations on Northern Range Development Project Nurseries. FAO/NRDP, Burao, Somalia. Project UTF/SOM/022: 27 MSp+map+appendix+nursery layout and procedural diagram.

Anderson, D. and Fishwick, R. (1984). Fuelwood consumption and deforestation in African countries. World Bank Staff Working Paper No. 704: 52 p.

Andrews, M. Nat. Hist. Unit, BBC. Pers. comm. 1985.

Anon. 1981. Forestry and wildlife sector study. Somali Democratic Republic Min. of Nat. Planning, Mogadishu: 31MSp.

Anon. No date. Practical notes on nursery techniques and afforestation methods for Somalia. No source: 86MSp. (In FAO Forestry library).

Armitage, F.B. (1985). Irrigated forestry in arid and semi-arid lands: a synthesis. IDRC, Ottawa: 160 p.

Aubreville, A. (1949). Climats forêts et désertification de l'Afrique tropicale.

Ayling, R.D. (1984). IDRC and wood energy research in Africa. FAO Tech. Consultation on Wood Energy Research in Africa. Addis Ababa: 7MSp.

Bayoumi, A.A. (1977). The role of shelterbelts in Sudanese irrigated agriculture with particular reference to the Gezira. Sudan Silva 22 (iii): 23-38.

Bergstrom, T. (1975). Trials with cutting from Frankincense tree (Boswellia sp.) in Debbis Nursery. Draft paper. Strengthening of Forestry and Wildlife Management Project, Somalia Min. of Livestock, Forestry Range: 6MSp.

Boguetteau-Verlinden. (1980). Study of impact of shelterbelts in Majjia Valley, NIger. In: Glick, F.A. 1984. A summary memorandum with selected references. USAID, Washington DC: 13-42.

Booth, G.A. (1982). Appraisal of planned assistance to the forestry sector under the CDA programme. Somalia. FAO, Rome: 35 p.

Booth, G.A. (1985). Ethiopian Highlands Reclamation Study. Forestry development study. UTF/ETH/037 Working Paper FAO, Addis Ababa: 49p+10 annexes+map.

Bosshard, W.C. (1966). Tree species for the arid zone of the Sudan. For. Dept. and UNDP For. Res. and Education Proj. Pamphlet No. 33. FRI, Soba, Khartoum.

BOSTID. (1980). Firewood crops. Shrub and tree species for energy production. National Academy Press. Washington DC: 237 p.

BOSTID. (1983a). Environmental change in the West African Sahel. National Academy Press. Washington DC: 96 p.

BOSTID. (1983b). Firewood crops. Shrub and tree species for energy production. Volume 2. National Academy Press. Washington DC: 92 p.

BOSTID. (1984a). Agroforestry in the West African Sahel. National Academy Press. Washington DC: 86 p.

BOSTID. (1984b). Casuarinas: Nitrogen-fixing trees for adverse sites. National Academy Press. Washington DC: 118 p.

Bowen, M.R. (1985). Ethiopia: selection and adaptation of tree species for plantation use in diverse ecosystems. Cons. Rept. ICD/UNDP/ETH/85/014, Parsons and Whittemore Lyddon Ltd., London, 74 p.

Brookman-Amissah, J. (1984). Management of Existing Fuelwood Resources. FAO Tech. Consultation on Wood Energy Research and Development in Africa. Addis Ababa: 15 p.

Bryce, J.M. (1974). Report on duty travel for FAO to Ethiopia and somalia. For. Dept., FAO, Rome: 8MSp.

Burley, J. (1984). Forestry Research Networks. In: Proc. IUFRO Plan. Wksp. for Asia on For. Res. and Technol. Transfer, Kandy, Sri Lanka, 1984. (eds. J. Burley and J. Stewart). IUFRO, Vienna, Austria.

Burley, J. and von Carlowitz, P. (eds.) (1984). Multipurpose tree germplasm. Proc. of a planning workshop to discuss international cooperation. ICRAF, Nairobi: 298 p.

Burley, J. and Salleh, M.N. (1985). Investment in Forestry Research. Paper for 12th Common w. For. Conf., Victoria, BC, Canada: 18 p.

Burley, J. and Wood, P.J. (1976). A manual on species and provenance research with particular reference to the tropics. Trop. For. Paper No. 10. Common w. For. Inst., Oxford: 226 p.

Doran, J.C., Turnbull, J.W., Boland, D.J. and Gunn, B.V. (1983). Handbook on seeds of dry-zone acacias. FAO, Rome: 32 p.

Eimera, J. van., Kayschon, R., Kazumova, L.A. and Robertson, C.W. (1964). Windbreaks and shelterbelts. Report of a working group of the Commission for Agricultural Meteorology. Tech. Note No. 59, WMO, Geneva: 188 p.

FAO. (1977). Strengthening of forestry and wildlife management. Somalia. Project findings and recommendations. Project DP/SOM/012. Rome: 36 p.

FAO. (1981). (Ethiopia) Report by Forestry sub-sector review and programming mission. Government of Ethiopia - FAO - UNDP Report W/P4029. Addis Ababa: 120MSp.

FAO. (1983). Village level reforestation in rural areas. Project findings and recommendations. Forestry for local community development programme. Project GOP/INT/363/SWE (Somalia): 53 p.

FAO. (1984a). Coordination and Monitoring Assistance to Forestry. Somalia. Project findings and recommendations. FO:DP/SOM/82/005:FAO, Rome:26MSp.

FAO. (1984b). Secretariat Note. The wood energy situation in Africa. FAO Tech. Consultation on Wood Energy Research and Development in Africa. Addis Ababa: 15 p.

FAO. (1984c). Secretariat Note. Survey of wood energy research and development capabilities in Africa. FAO Tech. Consultation on Wood Energy Research and Development in Africa. Addis Ababa: 10 p.

FAO. (1984d). Secretariat Note. Cooperation in wood energy research and development in Africa. FAO Tech. Consultation on Wood Energy Research and Development in Africa. Addis Ababa: 22 p.

FAO (1984e). Secretariat Note. Priorities in wood energy research and development. FAO Tech. Consultation on Wood Energy Research and Development in Africa. Addis Ababa: 16 p.

FAO/World Bank CP. (1983). Forestry sector desk study (for Ethiopia). Report No. 25/83: 19MSp+4 maps+4 annexes.

Felker, P. et al. (1983). Biomass production of Prosopis spp. (Mesquite) Leucaena, and other leguminous trees grown under heat/drought stress. For. Sci. 29(3): 592-606.

Felker, P. (1984). Economic, environmental and social advantages of intensively managed short rotation Mesquite (Prosopis spp.). Biomass energy farms. Biomass 5: 65-77.

Fjollio, P.F. and Thames, J.L. (1983). Collection, handling, storage and pretreatment of Prosopis seeds in Latin America. FAO, Rome: 45 p.

Finlayson, W., Child, G.S. and van Rensberg, J.J. (1972). Forestry and wildlife development survey mission. Somalia. DP/SOM/71/009: FAO, Rome: 86 p.

Fugalli, O. File note of 5/84 giving Work Norms for community tree planting and Sand Dune Fixation. FAO, Rome.

General Manager, Nat. Range Agency of Somaliland. Letter of 18 June 1985 to O. Fugalli.

Ghosh, R.C. (1977). Handbook on afforestation techniques. For. Res. Inst. Press, Dehra Dun, India, 411 p.

Gleisberg, C.F. (1966). Forestry development in the Republic of Somalia: Present conditions and future tasks. Report of Federal German Tech. Assistance Programme and Fed. German Research Institute for Forest and Timber Industry: 69MSp.

Gulcur, M. (1980). National plan to combat desertification, Somalia. FO:UNO/SOM/001/NSO Tech. Report. FAO, Rome: 86 p.

Hall, E. (1981). What are Somali's priorities for development? Somali Range Bull. No. 12: 20-3.

Hall, J.B. and Asghedom. (1981). Assessment (1979) of Eucalyptus species and provenances at Kigwe, Dodomia. Tanzania Division of Forestry Record. No. 18: 17 p.

Hamel, O. (1985). Production lijneuse en irrigué dans les périmètres aménases du Sahel nigérien et sénégalais. CTFT. Département des Recherches forestières, Dakar, Senegal: 55MSp.

Haron, P.A. Patterson, W.A. and Falconi, J. (1985). The role of forestry in dry Africa. T. For. 142:7.

Hemming, C.F. (1966). The vegetation of the northern region of the Somali Republic. Proc. Linn. Soc. London. 177(2): 173-250 +diagrams+maps.

Henry, P.W.T. (1973). Notes on and maps of the Eucalyptus plantations around Addis Ababa and the Menagesha State Forest, Ethiopia. Misc. Dept. 150, Land Res. Div., ODA, 10 p. + maps.

Hotte, E. (1984). Technical support to WFP assisted projects on rangeland development and reforestation projects. FO:TCP/SOM/2313. FAO, Rome: 76MSp.

Jackson, J.A.D. (1975). Proposals for tree species trials in Ethiopia. Common w. For. Rev. 54: 80-91.

Karani, A.A. (1983). National progress report on forestry in Somalia (1978-82). Report to 9th session Near East Forestry Commission, Nicosia: 19MSp.

Kass, S.R.L., Bingham L., Templemen F. and Felker, P. Optimization of environmental parameters to enhance rooting of cuttings in high biomass producing Prosopis alba (Mesquite/algarrobo) clones. J. Hort. Sci. In press.

Kaul, R.N. (1970). Afforestation in arid zones. Junk NV, The Hague.

Kenya Min. of Environment and Natural Resources (KMENR) and USAID. (1983). Proceedings of a national workshop on strengthening forest research in Kenya. Eldoret: 287p + 5 appendices.

Krezdorn, R. (1984). Establishment of nurseries. In: Project Working Papers vol. 1, Ethio-German Reforestation Project PN74. 2072 01.300. Addis Ababa.

Lanly, J.P. (1981). Tropical forest resources assessment project. Forest resources of Africa. Part II: country briefs. UN32/6.1301-78-04 Tech. Rept. 2. Report by FAO, Rome, as cooperating agency with UNEP.

MacFadyen, W.A. (1950). Vegetation patterns in the semi-desert plains of British Somaliland. The Geographical Journal 116, 4-6.

Malimbi, R.E. (1978). Performance of Eucalyptus species and provenances at Mtipa, Singida. Tanzania Silviculture Research Note No. 32: 13p + 17 appx.

Mazhar Ahmed Aran. (1978). The production of incense in Sanag. Degree thesis, U. of Somalia, Mogadishu.

Mooney, H.F. (1959a). Notes on a short visit to the Somaliland Protectorate. British M.E. Develpt. Div., Addis Ababa, 7MSp.

Mooney, H.F. (1959b). Report on the scope for forestry in Somalia. British M.E. Develpt. Div., Addis Ababa, 10MSp.

Mooney, H.F. (1959c). A report on the possibility for forest development in the Somali Republic. British M.E. Develpt. Div., Addis Ababa, 12MSp.

Mushi, J.A. (1981). Performance of Eucalyptus species and provenances in the arid areas of Tanzania. Tanzania Silviculture Research Note No. 40: 6 p.

Noronha, R. (1980). Village woodlots: are they a solution? Paper for Panel on Introduction and Diffusion of Renewable Energy Technologies. National Academy of Sciences, Washington DC: 35MSp.

Nshubemuki, L. and Maphole, J.E.N. (1984). Afforestation Research (Tanzania). IDRC-MR 99c. IDRC, Nairobi/Ottawa.

Ohlsson, Bo. (1978). A case study from Tiro, Ethiopia. 8th World For. Cong. paper: 5MSp.

Persson, Reidar. (1974). World forest resources. Review of the world's forest resources in the early 1970's. Royal College of Forestry, Stockholm.

Plucknett, D.L. and Smith, N.J.H. (1984). Networking in international agricultural research. Science 225: 989-93.

Sabas, E. (1984). Forestry Research at Malya, Tanzania.

Saleem, A.A. (1973). A study of shelterbelt experiences in semi-arid areas with particular reference to application in the Sudan. M.Sc. thesis, U. of Edinburgh: 124MSp.

Sandahl, L. and Ohlsson. Bo. (1978). The role of peasant associations in forestry development in Ethiopia. 8th World For. Conf. paper: 15MSp.

Shetty, H.R. (1984). Crop volume and outturn table for stand of Acacia nilotica. Ind. For: 586-90.

Somalia Ministry of National Planning. (1981). Forestry and Wildlife Sector Study. Draft report: 55MSp.

Somi, F.G.R. and Nshubemuki, L. (1980). An annotated list of research reports issued by the Silvicultural Research Section from Jan. 1951 to April 1980. Tanzania Silviculture Technical Note (New Series) No. 35: 39 p.

Southgate, B.J. (1983). Handbook on seed insects of Acacia species. FAO, Rome: 30 p.

UNDP/World Bank. (1984). Ethiopia: Issues and options in the energy sector. Rpt. 4741-ET, Joint UNDP/World Bank Energy Sector Assesst. Program.

USAID (1985). Somalia: CDA Forestry. A Progress Report to 6th CDA Forestry/Fuelwood Tech. Committee Mtg. CFI, Oxford, May 1985: 3 p. + 1 annex + table.

USAID Bureau for Africa. (1984). Report of Workshop on Forestry Program Evaluation. AID, Washington DC, 30 p + 4 appxs.

von Breitenback, F. (1961). Exotic trees in Ethiopia. Eth. For. Rev. 2: 19-39.

von Breitenback, F. (1962). National forestry development planning. Eth. For. Rev. 3/4: 41-68.

White, F. (1983). The vegetation of Africa - a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Paris.

World Bank. (1984). Desertification in the Sahelian and Sudanian zones in West Africa. FBRI W. Africa Projects Dept. Report No. 5210: 58 p.

World Resources Institute. (1985). Tropical Forests Project. Summary of Investment Requirements: Fuelwood and Agroforestry. Priority Actions 19867-91. Draft Proposals of 5 June 1985: 39MSp.

Wormald, T.J. (1984). The management of the natural forests in the arid and semi arid zones of east and southern Africa. A report for ODA: 18MSp + refs + 9 country reports.

RESEARCH PRIORITIES

Keith R. Shea
United States Department of Agriculture
Forestry Service
Washington, D.C.

During the workshop, a questionnaire was developed to obtain responses from the participants (Appendix III). The purpose was to estimate the importance of each of the seven proposals and where appropriate, the individual topics. Respondents were asked to rate their level of interest in the proposals and the individual topics as high, medium or low. Responses were grouped by country, donor or other. A total of 54 responses were obtained -- 27 individuals representing countries, 17 representing donor agencies and 10 others.

The individual responses were summarized as a percent of the total number of responses by country, donor, other and all responses, respectively. Since all respondents did not reply to all proposals or topics, totals in the tables will not add to 100 percent in many instances. The results which are summarized in the following tables should be considered only as a general indication of interest. No valid comparisons among proposals or individual topics can be drawn.

Furthermore, the final proposals included in this document have been modified based on the comments made during the workshop. Thus, these data are based on slightly different, earlier versions of the proposals.

In addition to ranking interest in the proposals and topics, several respondents made useful comments. Among these the following were frequently expressed.

- Mechanisms to ensure coordination among projects, donors and local institutions are essential.
- Proposals and topics related to ongoing work should receive highest priority.
- Pest management, mycorrhizae and symbionts should receive more attention.
- Forest soils are not treated adequately in the proposals.
- The countries expressed the need for networks and their desire to participate.

PROPOSAL NO. 1 -- Agroforestry Research and Development: Agroforestry for the solution of food, fodder and fuel shortages.

There was general agreement that topics 2, 3 and 4; 7 and 8; 9 and 10; and 11 and 12, respectively, could be combined to reduce the number of special interest topics.

Overall respondents rated this proposal as having high general interest. No low ratings were given (Table 1). However, interest in the individual topics varied greatly. Although some topics were of low interest to some, they were of high interest to others. This suggests special, often local needs, for specific circumstances.

Table 1. Percent response by interest level and category for Proposal No. 1 -- Agroforestry Research and Development

CATEGORY	INTEREST LEVEL		
	HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	85	15	0
Donors	41	59	0
Other	80	20	0
All	70	30	0
TOPIC INTEREST			
1. Biology and Reproduction of Capparaceae			
Country	11	30	56
Donor	6	41	35
Other	40	20	40
All	15	31	46
2. Hedges as Producers of Fodder			
Country	33	26	33
Donor	53	35	0
Other	80	20	0
All	48	28	17
3. Browse Management			
Country	37	44	11
Donor	59	12	12
Other	100	0	0
All	56	26	9
4. Fodder Productivity of Browse Species			
Country	37	52	7
Donor	65	12	22
Other	80	0	20
All	54	30	11

CATEGORY	INTEREST LEVEL		
	HIGH	MEDIUM (Percent)	LOW
5. Leaf Growth			
Country	22	18	52
Donor	6	53	29
Other	20	40	40
All	17	33	43
6. Fuelwood Productivity of Windbreaks			
Country	56	19	0
Donor	41	35	12
Other	30	40	30
All	46	39	9
7. Fuelwood Productivity on Saline Lands			
Country	52	30	12
Donor	35	18	29
Other	70	10	20
All	50	22	17
8. Fuelwood Production in Various Agroforestry Systems			
Country	70	15	4
Donor	59	18	6
Other	50	40	0
All	61	20	4
9. Production of Food by Woody Plants			
Country	37	33	26
Donor	59	24	6
Other	40	30	30
All	44	30	20
10. Indirect Effect of Woody Plants on Food Production			
Country	78	22	0
Donor	53	29	6
Other	80	10	10
All	70	22	4

CATEGORY	INTEREST LEVEL HIGH	MEDIUM (Percent)	LOW
11. Cacti for Fodder Production			
Country	11	15	63
Donor	0	35	47
Other	30	20	50
All	11	22	56
12. A Study of Atriplex for Fodder Production			
Country	2	56	30
Donor	0	41	41
Other	40	20	40
All	9	44	35

PROPOSAL NO. 2 -- Research and Development of Techniques for Natural Regeneration for Silvo-Pastoral Management of Existing Forest Resources.

This proposal was rated of high general interest by the majority of respondents (Table 2). Comments suggested that social and institutional research are needed to improve the management and adoption of the practices developed.

Table 2. Percent response by interest level and category for Proposal No. 2 -- Research and Development on Natural Regeneration Techniques for Silvo-Pastoral Management of Existing Forest Resources

CATEGORY	INTEREST LEVEL HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	56	26	7
Donor	70	12	18
Other	40	60	0
All	57	28	9

PROPOSAL NO. 3 -- Management of Indigenous Trees and Shrubs for the Rehabilitation of Degraded Rangelands in the Arid Zone of Northern Kenya.

Interest in this proposal was about equally divided among high, medium and low interest levels (Table 3). This perhaps reflects the relatively limited geographic area addressed in the proposal. Many of the suggestions in the proposal could, however, apply or be adopted to other arid African regions.

Table 3. Percent response by interest level and category for Proposal No. 3 -- Management of Indigenous Trees and Shrubs for the Rehabilitation of Degraded Rangelands in the Arid Zone of Northern Kenya

CATEGORY	INTEREST LEVEL HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	26	26	37
Donor	35	37	23
Other	20	40	40
All	28	31	33

PROPOSAL NO. 4 -- Selection and Genetic Improvement of Indigenous and Exotic Multipurpose Tree Species including Seed Collection, Handling, Storage and Exchange.

All respondents indicated considerable interest in this proposal; this suggests a strong need and potential for wide application of research results (Table 4).

Table 4. Percent response by interest level and category for Proposal No. 4 -- Selection and Genetic Improvement of Indigenous and Exotic Multipurpose Tree Species

CATEGORY	INTEREST LEVEL HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	89	7	0
Donor	82	18	0
Other	80	20	0
All	85	13	0

PROPOSAL NO. 5 -- Developing and Using Biotechnologies in Forestry and Agroforestry in the Sahelian and Sudano-Sahelian Zones.

Two categories of interest were assessed -- (1) general interest in the proposal as a whole and (2) specific interest in two topics, selection and genetic improvement, and biotechnology of symbiotic organisms (Table 5).

General interest in the proposal was about equally divided as high, medium and low levels. Interest in the topic concerning selection and genetic improvement was rated high by the majority of the respondents whereas a lower level of interest was expressed in biotechnology of symbiotic microorganisms. Discussions suggested that many participants were concerned about the high cost of this proposal and that they were not entirely clear as to the objectives. Unfortunately, time did not permit in-depth discussion of this proposal.

Table 5. Percent response by interest level and category for Proposal No. 5 -- Developing and Using Biotechnologies in Forestry and Agroforestry

	INTEREST LEVEL		
CATEGORY	HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	41	41	7
Donor	24	24	52
Other	20	20	60
All	32	32	32
TOPIC INTEREST			
1. Selection and Genetic Improvement			
Country	81	4	4
Donor	35	6	35
Other	60	0	30
All	63	4	18
2. Biotechnology of Symbiotic Organisms			
Country	37	48	4
Donor	12	35	35
Other	20	40	30
All	26	43	18

PROPOSAL NO. 6 -- Research and Development of Nursery Practices and Techniques for the Establishment and Management of Fuelwood Plantations including Harvesting and Distribution.

General interest in this proposal was relatively high among all respondents (Table 6). Over 50 percent of all respondents expressed a high level of interest in the following specific topics: nurseries; bibliographies for dry tropical regions; directories of forestry research and forestry development, respectively, and, lifelong forestry training.

Table 6. Percent response by interest level and category for Proposal No. 6 -- Research on and Development of Nursery Practices and Techniques for the Establishment and Management of Fuelwood Plantations.

CATEGORY	INTEREST LEVEL HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	82	11	4
Donor	59	29	12
Other	60	30	10
All	70	20	7
TOPIC INTEREST			
1. Nurseries			
Country	70	11	4
Donor	47	29	0
Other	70	10	0
All	63	17	2
2. Hardening Off of Gum Acias-Tissue Culture			
Country	30	44	15
Donor	6	53	24
Other	40	10	30
All	24	41	20
3. Developing a Site Characterization Method			
Country	44	33	11
Donor	41	41	0
Other	40	20	20
All	43	33	15

	INTEREST LEVEL		
CATEGORY	HIGH	MEDIUM (Percent)	LOW
4. Research in Plantation Establishment and Management			
Country	52	30	4
Donor	59	18	4
Other	20	30	30
All	48	26	9
5. Analytical Bibliographies for Dry Tropical Regions			
Country	67	7	11
Donor	35	47	0
Other	40	30	10
All	52	24	7
6. Directory of Forestry Research -- Dry Tropical Africa			
Country	63	15	11
Donor	47	12	29
Other	50	20	10
All	56	15	17
7. Directory of Forestry Development -- Dry Tropical Africa			
Country	67	7	11
Donor	53	12	24
Other	50	20	10
All	59	11	15
8. Lifelong Forestry Training			
Country	70	18	4
Donor	47	24	18
Other	80	0	0
All	65	17	7

PROPOSAL NO. 7 -- Nursery and Fuelwood Plantation Practices in Arid and Semiarid Zones of Northeast Africa.

General interest in this proposal was relatively high with 78 percent of the respondents noting a high interest level. Fifty percent or more of all respondents rated seven of the ten topics as having interest with respondents from countries generally indicating a somewhat higher level of interest than those representing donors.

Table 7. Percent response by interest level and category for Proposal No. 7 -- Nursery and Fuelwood Plantation Practices

CATEGORY	INTEREST LEVEL		
	HIGH	MEDIUM (Percent)	LOW
PROPOSAL INTEREST			
Country	74	15	4
Donor	76	18	0
Other	90	10	0
All	78	15	2
TOPIC INTEREST			
1. Sociological and Institutional Research			
Country	52	15	4
Donor	53	18	12
Other	40	40	10
All	50	20	7
2. Species/Provenance Research			
Country	78	4	0
Donor	59	35	0
Other	70	30	0
All	70	18	0
3. Seed Research			
Country	70	4	4
Donor	65	29	0
Other	70	30	0
All	70	17	2
4. Nursery Research			
Country	67	15	0
Donor	47	29	12
Other	40	50	10
All	56	26	6

CATEGORY	INTEREST LEVEL		
	HIGH	MEDIUM (Percent)	LOW
5. Plantation Research			
Country	74	15	0
Donor	41	35	6
Other	50	40	1
All	59	26	4
6. Plantation Management and Protection			
Country	76	11	0
Donor	42	47	6
Other	70	10	10
All	65	22	4
7. Basic Rhizosphere Studies			
Country	26	63	0
Donor	24	53	12
Other	60	10	30
All	31	50	9
8. Tree Improvement			
Country	70	18	0
Donor	59	18	12
Other	70	30	0
All	67	20	4
9. Basic Economic Studies			
Country	22	56	11
Donor	59	12	12
Other	80	20	10
All	44	35	11
10. Development of Tools and Their Use			
Country	33	48	4
Donor	41	24	29
Other	20	50	20
All	33	41	15

CLOSING REMARKS

J.A. Odera
IUFRO Workshop Chairman
(Kenya)

Mr. IUFRO Special Co-ordinator, Distinguished Delegates, Ladies and Gentlemen.

The long week has passed through quite quickly. To many of us it has been a week of tremendous opportunities for learning, information sharing and discoveries of results of some interesting work that has been going on in different parts of our continent. Many of us have been bewildered by some excellent work that has been reported from the francophone central and west Africa, that we have hitherto known very little about.

Ladies and gentlemen, Africa must strive to eliminate the artificial language barrier that currently inhibits free flow of information and communication between African scientists.

Trees, the vegetation and the technologies for managing these resources do not recognize political or language barriers. So we must act before we face an inevitable showdown.

The workshop in its deliberations has stressed, among other things, the importance of twinning, establishing networks between the north and south institutions. This is undoubtedly an excellent idea. But we must not lose sight of the benefits of horizontal twinning between south and south, information sharing both regionally and between the regions, eastern, central, southern, western and north Africa.

Ladies and Gentlemen, I would now like to express my sincere thanks to you individually and collectively for:

(a) Unanimously electing me as your Chairman. This has been a great honour to my country and to me in particular.

(b) I have been particularly moved by your unswerving support throughout the past week in observing meeting times, keeping to order and maintaining active participation. Short and conscience interventions, and observations etc. from the floor have provided very lively and fruitful debates.

(c) Your full commitment to the workshop has remained evident from day one, Thursday 9 January 1986 to the hour. Apart from a few participants who had to leave for other assignments, we have been running a full house throughout the week including the field trip to Machakos on Sunday.

At the end of the workshop, it is only natural to ask if the workshop has been successful and in which way. The success or failure of the workshop cannot be based on an evaluation of the proceedings of this work but rather on follow up initiative between our countries and the donor communities. Much of this will depend on your own aggressiveness.

Ladies and Gentlemen, Africa must not waste time reinventing the wheel. We must strive to use all available technologies that are economically feasible and appropriate in solving our problems.

Some people (not in this audience) have made vindicative assertions that Africa should remain preoccupied with nuts and bolts, while the developed world enjoys the comfort and affluence of high technology including word processors etc. This is a grossly misinformed opinion. Africa is not a newcomer to the advances in science and technology. Great centres of iron industries in western, central and southern Africa helped to produce the Nok culture about 300 BC, long before emergence of pottery industry. By AD 700 most of Africa was living in a thriving iron age.

Africa must therefore strive to regain its position in the world, by employing technologies indigenous or borrowed in cultivating trees, shrubs etc. in the north Sudanian and Sahelian zone.

We must look for and take a short-evolutionary pathway in technology assimilation and adoption. History is replete with contemporary success stories -- Japan, Korea, Hongkong, Taiwan, Singapore and now India -- countries who have made it without repeating the drudgery of industrial revolution that preceded development of modern technology and the industries in Europe. It can be done.

Distinguished participants, I would like to stress one statement that was expressed by my Minister, Hon. J. Nyagah -- "At the end of the day Africa must be developed by the Africans themselves ...." So to African foresters and scientists the challenge is with us. We must roll up our sleeves and do it ourselves.

Ladies and Gentlemen, please join me in expressing special thanks to our interpreters, those graceful voices that erased the barriers between the anglo- and franco-phone participants.

Permit me now Ladies and Gentlemen to express my special thanks to my two Vice-Chairmen, Mr. Matig from the Cameroon and Mr. Ouattara from Mali, who have given me loyal support during the week.

Finally, I would like to thank the many donor organizations whose generous support enabled the participation of many delegates. Please join me in paying special tribute to Mr. Oscar Fugalli, the IUFRO Special Co-ordinator who tirelessly prepared many background documents prior to the workshop, during the workshop and whom we are entrusting with ensuring the translation of our ideas into actual research projection.

Once again Ladies and Gentlemen, Thank you, "Asante sana, Kwaheri ya kuonana".

POST-MORTEM MEETING WITH DONORS AND TECHNICAL ADVISORS

Tim Resch
United States Agency for International Development
Washington, D.C.

The meeting was held January 15 and 16 in the International Council for Research in Agroforestry (ICRAF) conference room with twenty-two people from sixteen donor or international organizations attending.

The purpose of the meeting, as stated by Oscar Fugalli, the International Union of Forestry Research Organizations (IUFRO) Special Coordinator for Developing Countries, was to (1) solicit participants' reaction to the format of preparing and discussing draft project documents, (2) to provide opportunity for participants from donor organizations to state their agencies' position and philosophies, and (3) to provide a forum for other matters of interest. These discussions will assist in the development of workshops in Latin America, and possibly in dry Africa south of the equator and in the Middle East.

In general, the donors were happy with the organization and substance of the workshop feeling that it had resulted in good program interventions. It was felt useful to have national forestry leaders, researchers and participants from donor agencies at one meeting. Nevertheless, more emphasis on the multisectorial aspects of forestry, especially that of agroforestry, would have been preferred. Greater socioeconomic research emphasis was also desired. It was felt the workshop was a great success particularly as a result of the personal energies of Oscar Fugalli. It was felt useful for IUFRO to be directed at the single activity of research priority identification.

The World Bank (Jean Gorse) reported it was on the verge of a substantial policy shift away from production forestry to protection forestry in its African program. This view was discussed in the paper made available during the workshop (Desertification in the Sahelian and Sudanian Zones of West Africa). Cost reduction of forestry practices was going to be very important. Forestry versus other agricultural investment could be attractive for forestry if good proposals and technical packages could be offered. It was also felt the group must address the domestic urban fuelwood challenge.

Regarding the IUFRO special activities for developing countries--the World Bank was positive about the experience so far and was prepared to participate to a level of up to 20 percent core support for the proposed IUFRO Directorate of International Forestry and Extension (DIFRE) as a function of support from other donors.

Gorse finished by reporting on a planned operational workshop to be held in Oslo, Norway, in the summer of 1986, on managing the natural resource base in Africa, to be attended by some 10 people from the World Bank, 15 from Sahel countries and 15 from non-Sahel African countries. He said that the World Bank was ready to shift emphasis to a policy of rural development and that the future was large scale, multisectorial rural development activities.

Bill Howard, of Overseas Development Agency (ODA), approved the workshop's accomplishment of bringing anglophone and francophone forestry researchers together.

Regarding the IUFRO Research Planning Workshop for Latin America, Oscar Fugalli reported he had participated in an exploratory mission with Les Whitmore of the International Forestry Office of the United States Department of Agriculture Forest Service (USDA/FS), in October 1984. As a first phase with financial support of the USAID Regional Office for Central American Programs (ROCAP), three consultancies were undertaken on the role of multipurpose trees in the rehabilitation of degraded lands for three ecological zones. They were (1) humid lowlands, (2) dry lowlands and (3) highlands--both dry and humid. The meeting will occur after the IUFRO World Conference in Yugoslavia.

Hans Jurgen Von Maydell, a professor at the Forestry School in Hamburg, Germany, and an advisor to the Germany Agency for Technical Cooperation (GTZ) suggested the next workshop have an "others" category for discussion and priority setting to identify other research areas that might not have been covered in the draft project documents.

Von Maydell felt research should be integrated in an overall forestry development strategy and further that it be demand/problem oriented, not what is financially attractive and that research activities should be coordinated using both formal and informal networks.

In conclusion, Von Maydell said Africa has priority with German assistance because of its great need and that this workshop should help make funds available from BMZ/GTZ for national forestry research and planning.

Fugalli observed an "other" category was possible but, of course, there would be no preworkshop documentation. He would consider reserving some time for impromptu discussion on other possible topics. Fugalli noted that no concrete proposals would emerge as a result of an impromptu discussion unless there was a possibility of unsolicited research proposals being submitted for discussion.

Fugalli restated his position that IUFRO's role was that of a broker, who after the marriage would fade away to work on another of the many possible research areas, which could either be geographical or technical such as operational harvesting techniques in the humid forest.

Bjorn Lundgren, ICRAF, speaking as a private citizen in an observer status, wondered about the usefulness of coordination meetings. He had attended four coordination meetings in 1986 (FAO, WRI, and CDA and this meeting), all of which spoke of the forest research in Africa. He said no donors would commit to a project not in their format; that he was cynical about recommendations. He felt it was time in the meeting to confront donors for their intentions.

Ayling, IDRC in Nairobi, speaking for himself, his colleague in West Africa, Abderrahman Zaki, and IDRC, said there should be no question about IDRC support for these kinds of meetings; that it had been a useful workshop which increased donor and government understanding. He suggested a follow-up meeting to find out what has been accomplished and that IDRC would support such a meeting.

Ayling thought the workshop was a unique approach and that IDRC encourages linkages of different countries. He supported the idea of coordinators for these umbrella activities and cautioned great care was needed to encourage indigenous researchers.

He suggested an earlier icebreaker or starting with a full plenary session, then breaking up into work groups with appointed chairmen. The point was to determine methods to create more interaction, not to endorse working groups over the chosen format. He recognized language and regional problems and supported the idea of this group working together. IDRC was interested in supporting a directory of forestry research in Africa and further opportunities to bring scientists together.

Fugalli said working groups might be possible in Latin America because all would be in Spanish and researchers might have an ecotype bias. The suggestion for occasional half-day field sessions was a good idea. The site for the Latin American workshop is Huaraz, Peru, where there are many lines of forestry activity albeit not much forestry research.

Christel Palmberg of FAO noted the preparation of the draft project documents had put a high involvement in African participation. She felt the group format was a good opportunity to break the language barrier. In planning for the future, she was against working groups but did like the idea of occasional breaks for field visits.

Ian Morison, of USAID Science and Technology Bureau (ST) reported that two years ago USAID employees met to identify for USAID, top forestry research priorities. Forestry support for agricultural production and multipurpose trees (MPT) were identified as priorities. These IUFRO regional meetings have been and will continue to be important to USAID in the elaboration of its program. His bureau had developed a project--Forestry/Fuelwood Research and Development (F/FRED)--which was approved for $40 million (U.S.) and 10 years.

The Asia portion of F/FRED was MPT networking and USAID financing three components: (1) research capability enhancement, (2) networking of institutions, and (3) cross cutting issues such as information systems and data base management. A contract for $10 million (U.S.) had been let to Winrock International with the project base to be in Bangkok, Thailand.

Morison explained that the Senior Assistant Administrator for the ST Bureau, Dr. N. Brady, does not feel his office should be directly funding research, but rather act as a catalyst for other funds. There is a presumption that there are other funds for research and there is enough research going on to network.

In summary, Morison said that forestry had a priority within USAID. In the next couple of months, he would be attempting to work out a program with an emphasis on a network approach. The task will be to identify where research is going on.

Fugalli said USAID was a principal pillar in the IUFRO effort. It had been important as a stimulant and in financing the effort.

Bill Howard, of ODA, said he found the draft project documents useful especially where ODA bilateral programs, such as found in Botswana and Somalia, can build national research programs. ODA's contribution would be to pick up national elements and to design national activities that fit in with larger programs.

Chuck Lankester of UNDP said there was a strong need for a concerted follow-up. He suggested donors identify what is important and act or hire an international coordinator such as FAO providing specific responsibilities. He said he was impressed by USAID follow-up to the Kandy workshop and felt that USAID had put its money where its mouth is.

Regarding the WRI call to action, he noted compared to other regions Africa had the smallest amount of activity over the next five years, not because of lack of need but because of lack of staff. He said there was unanimity that the level of support indicated, i.e., twice present expenditures, was a minimum target and that it looked as if this target was going to be attained and, perhaps, doubled again. He said the problem in Africa is building human resources over the next five years. He said research with a strong training/extension component was a priority and urged investments in human resources. Lankester said the WRI report had been sent to all governments including the ministries of planning, financing and natural resources.

Fugalli observed most donors act principally on a bilateral basis. The solution was for donors to develop with countries bilateral country-specific forestry research. The need will then arise from regional networking projects. He said it was most important that country components were financed.

Lundgren spoke against zonal program networks based on bilateral projects. ICRAF was faced with this problem in implementing AFRENA activities in the SADAC and East Africa countries. He said many donors have technical advisors unwilling to accept others' ideas. The result loses the original idea. From Lundgren's personal experience, he found that to negotiate at the national level is difficult. He said donors at meetings need to agree to be flexible on components, need to have a predisposition to openness and recognize they may have to yield on biases.

Fugalli said the follow-up to the workshop would be a mailing of the proceedings--actually the finalized project documents with connecting tissue would be sent, of course, to all participants and also under a cover letter by Dr. Buckman to the appropriate planning agencies and to donor headquarters. Conversations could then be initiated on a bilateral basis.

Lundgren expressed a concern that agroforestry would lose its hard-fought identity of being multidisciplinary if IUFRO's program only stressed forestry.

Fugalli observed the paper IUFRO commissioned for the workshop on agroforestry was done by two ICRAF staff members, that ICRAF has funds from two donors to support two agroforestry networks and that the head of the IUFRO working party on agroforestry was an ICRAF staff member. He thought relationships were well defined, that ICRAF's strengths in agroforestry were well recognized.

Fugalli restated that IUFRO will not implement research. Its role is that of a broker, to identify problems to be researched and those problems must be of concern to more than one country. It will draw the attention of governments and donors to the situation. The follow-up to the problems is left to the countries and the donors while IUFRO moves on to other problems.

Fugalli added that it might take action to keep the situation in front of the governments and donors and to restate the projects when necessary. In general IUFRO was described as a loose umbrella of some 200 working groups that exist through individual volunteer efforts.

Jeff Burley, of IUFRO, went on to explain that the intention is simply to share IUFRO's normal pattern of operation with developing countries; that IUFRO's specialized small group meetings are highly productive and that the World Bank, UNDP and USAID recognized IUFRO's strength in sharing information. As travel costs are normally borne by the scientists' host institution, a proposal exists in IUFRO to have available travel grants for developing country scientists to attend IUFRO and other international meetings.

Fugalli noting the late hour asked if he had concurrence for the distribution of the proceedings. The group was affirmative. He asked if the process of Draft product documents in the UN style was a useful approach. Again the group was affirmative. Fugalli expressed regret the seven papers differed so much in styles noting that authors are like artists.

Resch reminded Fugalli that sociological, economic and policy research considerations had been inserted into the draft documents and asked that the draft project documents prepared for the LA workshop also have this broad identification of constraints to problem solution and not confine the research to the biological limitations.

Fugalli responded to the affirmative but cautioned that the time frame from LA was shorter than that allowed for Africa and that three explanatory documents were already being prepared.

Fugalli thanked the group for their patience and time. The group reciprocated.

Ron Ayling
IDRC
Box 62084
Nairobi, Kenya

Justus M. Byagagaire
Regional Office
Nairobi, Kenya

Jeff Burley
Oxford Forestry Institute
South Parks Road
Oxford, OX1 3RB, England

Francis Cailliez
45 Bis Av. De la Belle Gabrielle
g4130 Nogent/Marine France

Lester W. Carlson
351 St. Joseph Blvd.
Hull, Quebec, Canada K1A 1G5

Oddvar Haverahen
Agricultural University of Norway
1432 Nlh-Aas, Norway

Bill Howard
Elad House, Stag Place
London SWE 5DH, England

Chuck Lankester
Room 2024
No. 1 U.N. Plaza
New York, NY 10017

Bjorn Lundgren
P.O. Box 30677
Nairobi, Kenya

Ian G. Morrison
ST/FENR SA-18
Washington, D.C. 20523

Godfrey W. Nebo
Forestry and Forest Industries
GTZ HQ
Post fach 5180
6236 Eschborn 1 bei Frankfurt/Main
Federal Republic of Germany

Christel Palmberg
Forest Resources Development Branch
00100 Roma, Italy

S. Tahir Qadri
Forestry and Natural Resources
P.O. Box 699
Khartoum, Sudan

Tim Resch
USAID/Forestry Support Program
FSP Room 1208 RPE
USDA/FS P.O. Box 2417
Washington, D.C. 20513

Paivio Riihinen
University of Helsinki
Unionink 40 B,
00170 Helsinki, Finland

James R. Seyler
USAID/REDSO/ESA
P.O. Box 30261
Nairobi, Kenya

Keith R. Shea
USDA/FS P.O. Box 2417
Washington, D.C. 20513

Kees Soels
P.O. Box 20020
3502 La Utrecht
Netherlands

H.J. Von Maydell
fuer Forst/ind Holzwirtschaft
Leuschnerstr. 91
2050 Hamburg
Federal Republic of Germany

Katsura Watanabe
JICA
c/o JICA Office in Nairobi, Kenya

Peter Wood
ICRAF
P.O. Box 30677
Nairobi, Kenya

Abderrahman Zaki
CRD I
BP 11007, CD Annex
Dakar, Senegal

POST-MORTEM MEETING WITH COUNTRY REPRESENTATIVES

Les Carlson
Canadan Forestry Service
Canada

As with the donor-IUFRO meeting during the morning of January 16, 1986, the afternoon "Post-Mortem" meeting with country representatives dealt with comments on workshop conduct and activities with special reference to improving future IUFRO planning workshops. The meeting was attended by Hans-Jurgen von Maydell (Chairman), Oscar Fugalli, Jeffrey Odera, Christel Palmberg, Eyog Matig, Edouard Bonkoungou, Jeffrey Burley, Keith Shea and Les Carlson.

The morning discussion with the donors was reviewed and similar questions were directed to the country participants. The major concerns were:

1) The preparation of a planning workshop requires close contact with the participant countries and frequent follow-up with the local organizers.

2) National contributions, while solicited, were not forthcoming at or before the meeting. It was suggested that project proposers stick to the strict schedules set down by the workshop coordinator.

3) Closer contact between donors and participant countries is required if a progressive research strategy for the problem areas is to be developed, thus making project development easier.

4) Since IUFRO relates to research organizations, care should be taken in the future to involve regional universities in the workshop.

5) Following on from the workshop participant countries should, in collaboration with the donors, develop national projects and present them to the donor agency as soon as possible in order to fit into the donor's budgetary process.

6) The development of project costs is difficult and both participant countries and donors need to consult each other more closely to arrive at appropriate and more accurate costing of projects.

7) The participants, according to their own operating policies, will probably report to their governments on the workshop. These reports should be directed to the appropriate planning ministries that interface with the donors (not always the forestry agency).

8) Short term research can be attached to development projects if they support project goals. However, there is a definite need for a long term commitment to research that is not tied to development projects.

9) The development, execution and termination of projects is important to monitor. Burkina Faso has a National Research Commission which annually reviews country priorities for forestry and rates on-going projects according to their relevance.

Such organizations may be needed in other countries to keep the research strategies on track.

10) Overall it was felt that the workshop achieved its goals and was a good exercise for both the participants and donors. It was also suggested that future workshops follow a similar format, yet allow some special time for ad hoc project development.

APPENDIX I: AGENDA

IUFRO Research Planning Workshop for AFRICA
(Sahelian and North-Sudanian Zones)

Nairobi, Kenya, 9 - 16 January 1986
(Kenyatta International Centre, Room 2)

Thursday, 9 January

09 15	Participants assemble in Meeting Room 2
09 30	Arrival of the Hon. Minister of Environment and Natural Resources of Kenya
09 35 - 09 45	The Representative of IUFRO calls the meeting to order and gives the floor to the Hon. Minister who will deliver an address of welcome
09 45 - 09 55	The Representative of IUFRO gives IUFRO's address
09 55 - 10 15	The Representative of FAO delivers the keynote address on the theme: Increasing Productivity of Multipurpose Lands
10 20 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 1: Agroforestry
14 00 - 15 30	Topic 1: (cont.)
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	Topic 1: (cont.)

Friday, 10 January

09 00 - 10 30	Topic 2: Management of the Natural Vegetation
10 30 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 2: (cont.)
14 00 - 15 30	Topic 2 (cont.)
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	Topic 2 (cont.)

Saturday, 11 January

09 00 - 10 30	Topic 3: Tree Improvement
10 30 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 3: (cont.)
14 00 - 15 30	Topic 3: (cont.)
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	Topic 3: (cont.)

Sunday, 12 January

	BB (Beer Break)

Monday, 13 January

09 00 - 10 30	Topic 4: Biotechnologies
10 30 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 4: (cont.)
14 00 - 15 30	Topic 4: (cont.)
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	Introduction to the COSPRO/AFRENA Programme by the Director of ICRAF

Tuesday, 14 January

09 00 - 10 30	Topic 4: (cont.)
10 30 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 5: Plantation Forestry
14 00 - 15 30	Topic 5: (cont.)
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	Topic 5: (cont.)

Wednesday, 15 January

09 00 - 10 30	Topic 5: (cont.)
10 30 - 11 00	Coffee/Tea Break
11 00 - 12 30	Topic 5: (cont.)
14 00 - 15 30	Slide projection on ICRAF's activities
15 30 - 16 00	Coffee/Tea Break
16 00 - 17 30	WHAT NEXT? An informal closing ceremony

Thursday, 16 January

Meetings of and with donors, if it is so wished

APPENDIX II: LIST OF PARTICIPANTS

IUFRO RESEARCH PLANNING WORKSHOP FOR AFRICA

(Sahelian and North Sudanian Zones)
Kenyatta International Centre, Nairobi, 9-16 January 1986

Chairman: J. ODERA (Kenya)
Vice Chairmen: E. MATIG (Cameroon)
M. OUATTARA (Mali)

BURKINA FASO

Edouard G. BONKOUNGOU
Directeur de l'Institut de Recherche
en Biologie et Écologie Tropicale (IRBET)
BP 7047
Ouagadougou

Martin MANTORO
Chef de Division Forêt
Ministère de l'Environnement
et du Tourisme
BP 7044
Ouagadougou

Abdou Salam OUEDRAOGO
Directeur des Semences Forestières
c/o Administration Forestière
BP 7044
Ouagadougou

CAMEROON

Eyog MATIG Oscar, Chef
Antenne des Recherches Forestières
BP 222
Maraoua

André TIAYO, Chef de chantier ONAREF
CARE/ONAREF Agroforestry Project
BP 57
Mokolo

CHAD

Nandoumabé ALLARABAYE
Ingénieur des Eaux et Forêts
BIEP/MEADR
BP 447
N'Djamena

Moulnang TAL, Directeur des Forêts,
Chasses et de la Lutte contre la
Désertification
BP 447
N'Djamena

ETHIOPIA

Ato BERHANU HIKA, Head
Forestry Research Centre
Natural Resources, Conservation and
Development Division
Ministry of Agriculture
P.O. Box 1034
Addis Ababa

GAMBIA

Foday BOJANG, Assistant Director
Forestry Department
Ministry of Water Resources
and Environment
5, Marine Parade
Banjul

KENYA

Zachariah AMAHWA
Assistant Chief Conservator of Forests
P.O. Box 30513
Nairobi

Charles KIMATHI KIRIINYA, Silviculturist
P.O. Box 74
Kikuyu

D.K. MBENGEI
Provincial Forest Officer (NEP)
Box 89
Garissa

Danson MUTUNGA MUSAU, Head
Forestry Entomology and Zoology
P.O. Box 74
Kikuyu

J. ODERA, Deputy Director
Forestry Research Department
Kenya Agricultural Research Institute
P.O. Box 74
Kikuyu

George OMOLLO ONDENGE, Agriculturist
P.O. Box 67839
Nairobi

A.D UVOO, Provincial Forest Officer
P.O. Box 80078
Mombasa

Moses WANGA
Senior Human Settlements Officer
National Environment Secretariat
P.O. Box 67839
Nairobi

Matthias WERE
Deputy Director of Agriculture Nairobi
Ministry of Agriculture and Livestock Dev.
P.O. Box 30028
Nairobi

MALI

Mamadou OUATTARA, Directeur Adjoint
Institut National de la Recherche
Zootechnique Forestière et
Hydrobiologique (INRZFH)
BP 1704
Sotuba Bamako

Ousmane SANKARE, Chef de la Division de
la Recherche Forestière et Hydrobiologique
INRZFH
BP 1704
Sotuba Bamako

MAURITANIA

Diack TALEB, Homologue expert recherches
forestières
Ministère du Développement Rural
BP 170
Nouakchott

NIGER

Aboubacar ISSA
Chef du Département de la Recherche
Forestière
INRAN
BP 225
Niamey

NIGERIA

M.A. OGIGIRIGI, Assistant Director
Forestry Research Institute of Nigeria
P.M.B. 5054
Ibadan

SENEGAL

Amadou Ibra NIANG
Directeur du CNRF/ISRA
BP 2312
Dakar

Bocar SALL, Directeur des Eaux,
Forêts et Chasses
Ministère de la Protection de la Nature
BP 1831
Dakar

SOMALIA

Abdullahi Nur ALIO
Director Agricultural Research Institute
Ministry of Agriculture
Mogadishu

Mohamed A. IKAR, Director
Anti Desertification Unit
National Range Agency
P.O. Box 1759
Mogadishu

SUDAN

Ahmed El NOURI Ahmed, Head of Silviculture
Research Station
Forest Research Centre
P.O. Box 658
Khartoum

Mohamed Ahmed EL RASHEED
Head, Department of Forestry
Faculty of Agriculture
University of Khartoum
Shambat, Khartoum North

Tageldin Hussein NASROUN, Director
Forestry Research Centre
P.O. Box 658
Khartoum

Ali Ahmed SALEEM, Director of
Afforestation/Shelterbelt Section
FAO/Netherland Project
for Development of Fuelwood for Energy
P.O. Box 658
Khartoum

TANZANIA

Gabriel KITAMBI, Acting Director-General
TAFORI
P.O. Box 30072
Kibaha

Jumanne A. MAGHEMBE, Head
Department of Forest Biology
Sokoine University of Agriculture
P.O. Box 3010
Morogoro

Jonasai MAPHOLE, Forest Research Officer
Arid Zone Afforestation Research
P.O. Box 1576
Dodoma

Ladislaus NSHUBEMUKI, Senior Forest
Research Officer
TAFORI
P.O. Box 45
Mafinga

OTHER PARTICIPANTS

AFRICAN DEVELOPMENT BANK

Justus Muheru BYAGAGAIRE,
Principal Agronomist
Regional Office
P.O. Box 52617
Nairobi, KENYA

AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH (ACIAR)

Anthony OCKWELL, Agricultural Economist
ACIAR/CSIRO Project
P.O. Box 41567
Nairobi, KENYA

CANADIAN FORESTRY SERVICE

Lester W. CARLSON
Director of Research
351 St. Joseph Blvd.
Hull, Quebec, CANADA K1A 1G5

DANIDA

Henrik KEIDING
DANIDA Forest Tree Seed Centre
Krugerupvej 3A
3050 Humlebaek, DENMARK

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)

Lars GRAUDAL
Forest Research Development Branch
Via delle Terme di Caracalla
00100 Roma, ITALY

Jean-Paul LANLY, Director
Forest Research Division
Via delle Terme di Caracalla
00100 Roma, ITALY

Christel M. PALMBERG (Ms)
Forest Resources Development Branch
Via delle Terme di Caracalla
00100 Roma, ITALY

Project TCP/GBS/4506	Ana Maria ALMEIDA DE SA (Ms.), Chef Service des Forêts et Chasses Ministère du Développement Rural B.P. 71 Bissau, GUINEA-BISSAU
FINNIDA	Göran HALDIN, Adviser on Forestry and Forest Industries Box 276 00171 Helsinki 17, FINLAND
	Päiviö RIIHINEN Professor at the Faculty of Forestry University of Helsinki Unionink. 40 B 00170 Helsinki, FINLAND
	DARRELL SEQUEIRA Consultant Ecology, Dept. of Agriculture University of Helsinki FINLAND
FOREST ENERGY SECRETARIAT	Ola SALLNAES Faculty of Forestry Swedish University of Agricultural Sciences 77073 Garpenberg, SWEDEN
FORESTRY ASSOCIATION OF BOTSWANA	Colin MILLAR, Director P.O. Box 2088 Gaborone, BOTSWANA
FRANCE	Francis CAILLIEZ, Directeur Centre Technique Forestier Tropical (CTFT) 45 bis, Avenue de la Belle Gabrielle 94736 Nogent-sur-Marne
GERMAN AGENCY FOR TECHNICAL COOPERATION (GTZ)	Hans-Jurgen von MAYDELL Professor at the Bundesforschungsanstalt fur Forst- und Holzwirtschaft Leuschnerstrasse 92 2050 Hamburg 80, F.R.G.
	Godfrey W. NEBO, Project Operation Officer GTZ HQ Postfach 5180 6236 Eschborn 1 bei Frankfurt/Main F.R.G.
INSTITUTE FOR INTERNATIONAL COOPERATION IN AUSTRIA (IIZ)	Christian GUGGENBERGER, Project Manager P.O. Box 398 Mwanza, TANZANIA

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY (ICRAF)

Michel BAUMER, Senior Range Management Adviser
P.O. Box 30677
Nairobi, KENYA

Bjorn LUNDGREN, Director
P.O. Box 30677
Nairobi, KENYA

Peter WOOD, Senior Forest Management Adviser
P.O. Box 30677
Nairobi, KENYA

INTERNATIONAL DEVELOPMENT RESEARCH CENTER (IDRC) of Canada

R.D. AYLING, Program Officer
Box 62084
Nairobi, KENYA

Abderrahman ZAKI
Agent régional de programmes (Foresterie)
CRDI
BP 11007, CD Annexe
Dakar, SENEGAL

INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT (IFAD)

Abbas KESSEBA, Senior Technical Adviser
Project Management Department
Via del Serafico 107
00142 Roma, ITALY

INTERNATIONAL UNION OF FORESTRY RESEARCH ORGANIZATIONS (IUFRO)

Jeffery BURLEY, Director
Oxford Forestry Institute
South Parks Road
Oxford 0X1 3RB, U.K.

René CATINOT
Ancien Directeur Général du CTFT
Rue de l'Église
63450 St-Amant-Tallende, FRANCE

Christian COSSALTER, Ingénieur d'études et de recherches
CTFT
45 bis, Avenue de la Belle Gabrielle
94130 Nogent-sur-Marne, FRANCE

Yvon DOMMERGUES
c/o BSSFT (CTFT/CNRS/ORSTOM)
45 bis, Avenue de la Belle Gabrielle
94736 Nogent-sur-Marne, FRANCE

Oscar FUGALLI
Special Coordinator for Developing Countries
IUFRO
Schönbrunn
1131 Wien, AUSTRIA

Margareta SCHWEIGHARDT (Ms.), Translator
Special Programme for Developing Countries
IUFRO
1131 Wien, AUSTRIA

El Hadji SENE
Member of IUFRO's Executive Board from Africa
c/o Direction des Eaux, Forêts et Chasses
BP 1831
Dakar, SENEGAL

Christian TOMICZEK
Assistant to the Special Coordinator
for Developing Countries
IUFRO
Schonbrunn
1131 Wien, AUSTRIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Takeyoshi SUZUKI, Researcher
Forestry and Forest Product Research Institute
Shinjuku Mitsui Bldg.
2-1 Nishi-Shinjuku, Shinuku-Ku
P.O. Box 216
Tokyo 160, JAPAN

Katsura WATANABE, Forestry Adviser
JICA
Shinjuku Mitsui Bldg.
2-1 Nishi-Shinjuku, Shinuku-Ku
P.O. Box 216
Tokyo 160, JAPAN

MAB/KENYA ARID LANDS RESEARCH STATION (KALRES)

W.J. LUSIGI, Chief Technical Adviser
P.O. Box 147
Marsabit, KENYA

NETHERLANDS

Gerrit Paulus HEKSTRA, Ecologist
Ministry of the Environment
P.O. Box 450
2260 MB Leidschendam, NETHERLANDS

Gerrit Jan Bernhard RENES, Forestry Adviser
BP 1302
Ouagadougou, BURKINA FASO

	Kees SOELS, Head Research and Technology Section of the Directorate of International Cooperation Ministry of Foreign Affairs NETHERLANDS
NITHI TIMBER CO-OP SOCIETY (CANADA)	John HALL, Project Manager P.O. Box 17 Chuka, KENYA
NORAD	Oddvar HAVERAAEN Professor at the Department of Silviculture Agricultural University of Norway P.O. Box 42 1432 NIh-Aas, NORWAY
OVERSEAS DEVELOPMENT ADMINISTRATION OF THE UNITED KINGDOM (ODA)	ABELL, Forest Adviser Embu-Meru-Forestry Project P.O. Box 2 Embu, KENYA
	ARMSTRONG, Silviculturist EMI Forestry Project Box 2 Embu, KENYA
	Michael Roderick BOWEN, Forest Research Officer FCO (Mogadishu) ODA Somalia King Charles Street London SW1A 2AH, UNITED KINGDOM
	William J. HOWARD, Forestry Adviser Eland House, Stag Place London, SW1E 5DH, UNITED KINGDOM
SWEDISH AGENCY FOR RESEARCH COOPERATION WITH DEVELOPING COUNTRIES (SAREC)	Jan Olof LUNDBERG, Programme Officer 10525 Stockholm, SWEDEN
UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP)	Charles LANKESTER, Principal Technical Adviser 1 United Nations Plaza New York 10017 N.Y., USA
UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)	Jiri SKOUPY, Senior Programme Officer P.O. Box 47074 Nairobi, KENYA

UNITED NATIONS EDUCATIONAL SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

Livingstone DANGANA
Programme Specialist, Ecological Sciences
UNESCO Nairobi
P.O. Box 30592
Nairobi, KENYA

USDA FOREST SERVICE (USFS)

Keith R. SHEA, Associate Deputy Chief
for Research
P.O. Box 2417
Washington, D.C. 20013, USA

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY (USAID)

LeRoy DUVALL, Forestry Advisor
USAID Bujumburu
Bujumburu (ID)
Dept. of State
Washington, D.C. 20520, USA

Ian G. MORISON
Senior Forestry Research Advisor
ST/FENR SA-18
Washington, D.C. 20523, USA

Keith OPENSHAW, Regional Director
Energy Initiatives for Africa
P.O. Box 39002
Nairobi, KENYA

Tahir QADRI, Advisor
Forestry and National Resources
P.O. Box 699
Khartoum, SUDAN

Tim RESCH, Program Coordinator for Africa
USAID Forestry Support Program
PSP Room 1208 RPC
USDA/FS
P.O. Box 2417
Washington, D.C. 20013, USA

James R. SEYLER
Regional Forestry Advisor
USAID/REDSO/ESA
P.O. Box 30261
Nairobi, KENYA

WORLD BANK (WB)

Jean GORSE, Senior Forestry Specialist
WAPA C
1818 H-Street N.W.
Washington, D.C. 20008, USA

APPENDIX III: RESEARCH PRIORITIES

Country of Affiliation ________________ Name ______________

Proposal 1: Agroforestry research and development: Agroforestry practices for the solution of food, fodder and fuel shortages by M. Baumer & P. Wood

General Interest: High - Medium - Low

Specific Interest Level: (Circle your appropriate choice)

1.	Biology and reproduction of Capparaceae	H M L
2.	Hedges as producers of fodder	H M L
3.	Browse management	H M L
4.	Fodder productivity of browse species	H M L
5.	Leaf growth (Phase I)	H M L
6.	Fuelwood productivity of wind breaks	H M L
7.	Fuelwood productivity of saline lands	H M L
8.	Fuelwood productivity in various AF systems	H M L
9.	Production of food by woody plants	H M L
10.	Indirect impact of woody plants on food productions	H M L
	(study of the tree/crop interface)	H M L
11.	Cacti for fodder production	H M L
12.	A Study of *Atriplex* for fodder production	H M L

Comments:

Proposal 2: Research on, and the development of, natural regeneration techniques for the silvo-pastoral management of existing forest resources by E.G. Bonkoungou & R. Catinot

General Interest: High - Medium - Low

Comments:

Proposal 3: The management of indigenous trees and shrubs for the rehabilitation of degraded rangelands in the arid zone (northern Kenya and beyond) by H.F. Lamprey

General Interest: High - Medium - Low

Comments:

Proposal 4: Selection and genetic improvement of indigenous and exotic multipurpose tree species including seed collection, handling, storage and exchange by O. Souvannavong & C. Cossalter

General Interest: High - Medium - Low

Comments:

Proposal 5: Developing and using biotechnologies in forestry and agroforestry in the Sahelian and Sudano-Sahelian Zones (SSZ) by Y. Dommergues, J. Gorse, B. Dreyfus, A. Niang & S. Badji

General Interest: High - Medium - Low

Specific Interest Level: (Circle your appropriate choice)

1. Selection of genetic improvement of trees H M L
2. Biotechnology of the symbiotic microorganisms H M L

Comments:

Proposal 6: Research on, and development of, nursery practices and techniques for the establishment and management of fuelwood plantations, including water harvesting and distribution by C. Cossalter and O. Souvannovong

General Interest: High - Medium - Low

Specific Interest Level: (Circle your appropriate choice)

1. Nurseries: Evaluation of techniques used, dissemination of knowledge, programming of further research H M L
2. Hardening-off under Sahelian conditions of gum acacias propagated by tissue cultures H M L
3. Developing a site characterization method - as a method for assessment of reforested areas. Dissemination of knowledge H M L
4. Planning of further research in plantation establishment and management H M L

5. Preparation of analytical bibliographies specific to dry tropical regions in the field of nurseries, plantation establishment and management H M L
6. A directory of forestry research in dry tropical Africa H M L
7. A directory of forestry development in dry tropical Africa H M L
8. Lifelong training for forestry staff H M L

Comments:

Proposal 7: Nursery and fuelwood plantation practices in arid and semi-arid zones of north-east Africa by F.B. Armitage & J. Burley

General Interest: High - Medium - Low

Specific Interest Level: (Circle your appropriate choice)

1. Sociological and institutional research H M L
2. Species/provenance research H M L
3 Seed research H M L
4. Nursery research H M L
5. Plantation research H M L
6. Plantation management & protection H M L
7. Basic rhizosphere studies H M L
8. Tree improvement H M L
9. Basic economic studies H M L
10. Development of tools and their use H M L

Comments:

APPENDIX IV

FORESTRY RESEARCH NETWORKS - OBJECTIVES, PROBLEMS AND MANAGEMENT

J. Burley
Forestry Department
Oxford University
Commonwealth Forestry Institute
South Parks Road
Oxford
U.K.

ABSTRACT

The paper describes the objectives, benefits, principles and main types of problems of international research networks. Objectives and benefits include staff and skill development, technology transfer, provision of appropriate material and research guidelines, and yield of data that are more useful than the sum of individual collaborators' research. Principles and problems relate to the identification of a strong leading institution, encouragement and commitment of collaborators, financial and staff support from donors and twinned agencies at least in the early stages of a network, communication of research to collaborators and others, and technical problems such as germplasm transfer, flexible experimental design and comparable assessment.

INTRODUCTION

The recent IUFRO Regional Planning Workshop for Asia held in Sri Lanka during July 1984 enthusiastically adopted the concept of species networks in the introduction and improved management of multipurpose trees. During the workshop a seminar was conducted on the organization of research networks and the present note provides a written memorandum and indicates the major benefits and problems of networks.

The adoption of the species approach does not follow the IUFRO organization of forestry research by subject but rather it follows the pattern of the CGIAR, which has established international agricultural research institutes for single crops or groups of crops. Nevertheless both systems can be said to use networking in that a given IUFRO Working Party may establish comparative provenance trials of a single species in many countries while a CGIAR institute has satellite field stations or collaborating institutions which conduct comparative trials of improved varieties or management systems. Plucknett and Smith (1984) reviewed networking in international agricultural research.

THE CONCEPTS OF NETWORKS AND TWINNING

Statisticians, mathematicians, transport experts and economists use the term "network" in highly specialized senses and there is a large field of network analysis, critical path analysis and similar analytical and prescriptive techniques. For the purposes of forestry and agricultural research in developing countries, however, a network is an informal or formal arrangement of cooperation between institutions with similar conditions and problems but without the immediate resources to find answers to those problems individually. Networking is a concept most recently accepted by development agencies and developing countries as being a cost-effective mechanism for strengthening institutional capability and causing rapid change in application of research findings.

Networking is similar to, but extends, the concept of twinning, which is the agreement between two institutions to strengthen one by contributions of staff, training, equipment, materials or finance from the other. Twinning is often established between an institution in a developing country and one in a developed country but both institutions may be located in countries with similar development status. The UN principle of technical cooperation among developing countries, TCDC, also encourages such sharing of information, skills or resources.

Twinning may be extended to multiple twinning whereby one institution gives support to several or, vice versa, receives support from several. When such an arrangement is established to deal with specific research topics or species it may be considered a network and usually one of the collaborating institutions is assigned the leadership and coordination of the network. Cooper (1984) reviewed the twinning of institutions as a mechanism for transferring technology, training staff and building management capability; the professional relationships established between the cooperating entities offer complementarity and flexibility over time. In the same paper she also examined the design issues in establishing twinning such as the substance of the agreement, the design of services to be rendered, logistical and administrative support, and human behavioural factors.

A network approach generally reduces costs, minimizes duplication, boosts efficiency and leads towards national self-sufficiency in research capability or management. The benefits of a network are therefore most valuable in countries with limited funds and scientific manpower. In their historical review of agricultural research Plucknett and Smith (1984) recognized seven main principles for success in networking:-

(i) The problem must be clearly defined and a research agenda drawn up.
(ii) The problem should be common to many countries.
(iii) Strong self-interest must exist in each collaborator.
(iv) Participants must be willing to commit resources.
(v) Outside funding should be made available to facilitate the birth and early functioning of a network.
(vi) Staff from participating institutions should have sufficient training an expertise to make a contribution.
(vii) Networks must be guided by strong and efficient leaders who have the confidence of the participants.

I would add two other principles for networks to be effective:-

(i) Participants should be prepared and encouraged to share the results of national activities related to the network's research through formal publications, informal reports, newsletter and conference papers;

(ii) Participants should demonstrate, or include preparations to establish, mechanisms for extension of technological findings to the "user", whether forest department, industrial plantation company, rural community or individual farmer.

EXISTING NETWORKS

More than 100 international agricultural networks are currently operating (Plucknett and Smith, 1984). Many of these are concerned with comparative testing of improved crop germplasm but others deal with agronomic problems and farming systems, machinery development and socio-economic constraints on development.

In forestry cooperative programmes have existed between North American states and companies for many years including provenance research (*e.g.* the Southwide pine seed source study), soil fertilization (*e.g.* the US cooperative fertilizer study) and tree breeding (*e.g.* University-Industry cooperatives based at the Universities of Florida, North Carolina State and Texas A and M).

International networks of provenance trials have been established for a range of species, often identified with specific IUFRO Working Parties; the leading centres for these have included CFI, Oxford, UK (Central American tropical pines and arid zone hardwoods), CSIRO, Canberra, Australia (Australian species of *Acacia*, *Casuarina* and *Eucalyptus*), CTFT, Paris, France (African hardwoods and Pacific insular eucalypts), DTSC, Humlebaek, Denmark (Asian tropical pines, *Gmelina* and *Tectona*), FAO, Rome Italy (arid zone hardwoods), NAS, Washington, USA (nitrogen-fixing trees and species for the Sahel zone) and NFTA, Hawaii, USA (nitrogen-fixing trees). Progress reports on these trials appear frequently in FAO's Forest Genetics Resources Newsletter and in proceedings of meetings organized by IUFRO working parties S2.02-08 (Tropical species provenances), S2.02-09 (Eucalypt provenances), S2.03-01 (Breeding tropical species excluding eucalypts) and S2.03-10 (Breeding eucalypts). Examples of network structures and activities are given as Appendix A (existing CFI network for tropical pine provenance research) and Appendix B (proposed Commonwealth Science Council agroforestry network for anglophone Africa).

PROBLEMS OF NETWORKS

Nine main groups of problems have been experienced in the existing forestry research networks. These are outlined below, together with some possible approaches to minimizing their impacts.

1. *Choosing species or topics*. With constantly reducing finance for research it is imperative to maximize the cost-effectiveness of available resources by working on species and subjects that have the widest potential socio-economic benefit. Traditionally IUFRO has developed a working party to cover a given group of species and/or subjects whenever a group of individual scientists sees a need and is prepared to work together, personally, voluntarily and with no external inputs of resources except perhaps germplasm. Recently, however, attempts have been made to prioritize research topics globally (*e.g.* World Bank and FAO, 1981) or regionally (*e.g.* the IUFRO Regional Planning Workshop at Kandy, Sri Lanka, 1984); species priorities for conservation, evaluation and improvement have been identified by the FAO Panel of Experts on Forest Gene Resources and at the ICRAF/CFI/IBPGR Workshop on Multipurpose Tree Germplasm, Washington, USA, 1983 (see Burley and von Carlowitz, 1984).

2. *Identifying the leading centre*. As indicated above successful networks need strong and efficient leaders, not dictatorial agencies but organizations and individuals that can provide firm leadership, sympathetic guidance, and relevant information, experimental designs and, where necessary, analyses. In a paper for the IUFRO Congress in Kyoto, Japan, the World Bank and FAO (1981) identified some 90 centres globally that could be considered to have the resources and knowledge to

merit recognition as leaders in particular research topics. At the IUFRO Workshop in Kandy several species networks were agreed and leading centres were chosen by negotiation among the participants, recognizing current capabilities and equalizing the work-load as far as possible.

For most of the existing international forestry networks the leading centre is located in a developed country remote from the plantation sites and, with the exception of CSIRO, remote from the natural sites or origin of species and population germplasm. This is neither fortuitous nor a hint of incipient neo-colonialism but a reflection of the support given by bilaterial donor agencies to international development by encouraging their own national institutions to undertake research (e.g. germplasm exploration, conservation, evaluation, etc.) for the benefit of many developing countries.

The donor agencies and their national institutions have agreed on species allocations with the help of FAO's Panel of Experts on Forest Gene Resources and they can provide seed from a wide range of sources that it would be impractical for each participating organization in a network to collect; for example, the CFI programme of provenance research in *Pinus caribaea* and *P. oocarpa* has collected and made available up to 50 seedlots for trials on approximately 500 sites in 50 countries. Assistance is then provided with design, assessment, analysis, interpretation, taxonomic research, chemical analysis, wood quality determination, etc., wherever national institutions cannot undertake such work for themselves. One of the functions of the leading centres for the networks identified at the Kandy Workshop will be to determine the capabilities of participants and their needs for external support.

3. Identifying network participants. The Kandy Workshop recognized from among those attending, some potential participants in the identified multipurpose tree species networks. However, such networks should not be considered as clubs with restricted membership. One of the great advantages of networking is that a greater number of field sites provides increased information on the effects of interactions between site and genotype or management. Leaders and members of networks should constantly be seeking new participants able to meet the principles introduced earlier.

4. Encouraging active participation and providing resources. Even when potential participants can be identified they may not see the importance of joining a network, or they may not have sufficient resources to follow the agreed research agenda. The leader should clarify the benefits, quantifying them where possible on the basis of production gains in similar conditions or species, and seek sources of financial or personnel support.

   Additional financial support may be obtained from donor agencies once a network's objectives, research agenda, leading centre and actively participating centres are identified and prepared in a suitable form. The form may differ between donors and advice should be sought from the forestry advisor in each agency. Some agencies prefer to finance national projects individually, others can consider an entire network, while yet others prefer subjects that are part of a network's overall operation, e.g. training courses or post-graduate education, or workshops.

Personnel support comes from such courses and workshops eventually, but in the immediate future additional staff may be provided through twinning with better endowed institutions.

5. Communications and feedback. To be effective the results of all the participants' research should be combined (at a workshop or by the leader), circulated to all collaborators, and published for the benefit of others. Feedback from the field to the leader is often sporadic (because of shortages of staff and skills) or hesitant (because of fears of loss of national or personal data). In addition to the support described in Section 4 above, these constraints may sometimes be met by allocating national staff temporarily to the leading centre to assist with the combined analysis and publication; this is particularly effective when the leading centre is associated with a university that can accept post-graduate students to work on network data or problems.

6. Plant material. Most of the existing forestry research networks and all of the multipurpose tree networks identified at the Kandy Workshop require exchange of plant material between countries; this is usually in the form of seed, and large quantities will be required before the end of the present century for network activities, national research programmes and extensive rural use and plantation development. Such seed should be accompanied by certificates of origin and quality (see Jones and Burley, 1973) and of plant health (see Ivory, 1984); it is commendable that many countries now adhere to international agreements on plant quarantine but this sometimes has the effect of delaying seed imports with consequent loss of viability. Leaders and participants in networks should ensure that seeds are "met" at airports, cleared through customs and plant health formalities efficiently and despatched to field sites or stores immediately. Since for many species seed supplies are difficult and costly to obtain, the greatest efficiency should be sought in their use.

   It is possible that tissue culture and micropropagation will be developed in the foreseeable future to an extent that permits rapid and healthy international transfer of improved germplasm. If so there will undoubtedly be delays before customs and quarantine officials become familiar with such material and rules become adjusted for its handling. Micropropagation has already been used to transfer oil palm germplasm from Nigeria through Britain to Malaysia and leaders of multipurpose tree germplasm networks could well seek advice from Malaysian participants on means of expediting such transfers.

7. Amount of material for comparative testing. When a network is concerned with evaluating germplasm (e.g. species, provenance, family or clonal tests) it has several aspects that are in mutual conflict. As the number of field sites for tests increases, with consequent increase in environmental variation, the precision of estimating genotype-site interaction effects may improve but the amount of seed required increases also; at the same time, if all network participants are in a position to supply seed of some local native origins or exotic populations of the species concerned, the number of seed lots increases and not all are likely to have future application in all sites.

   It is often counter-productive to ask participants to test too many treatments. The network leader therefore has to strike a balance between recommending all participants to test everything and trying to identify specific seedlots for individual test sites; the latter option may not be feasible in the early stages of evaluating a new species when little is known about the response of the species to specific environmental or managerial conditions.

8. Experimental design. The leader of a research network is commonly expected to produce experimental designs for field trials, especially where participating centres and scientists are not familiar with the basic principles of design and analysis (despite the sixth principle for success described earlier). Depending on the material and sites to be tested (see Section 7 above) designs may be simple (e.g. randomized complete blocks) or more complex (e.g. incomplete block designs, lattices, etc.); they may be fixed for all sites or vary between sites in terms of type of design, degree of replication and size of plot; each field site may have a different set of entities for test (e.g. different provenances) (see Burley and Wright, 1984). Management could be uniform and imposed by the leader, agreed to be uniform by negotiation, or varied between sites.

   Whatever is agreed, the leader should suggest flexible designs, provide management manuals, and offer sources of assistance with assessment and analysis, remembering throughout that although combined analysis in the network concept offers more information than the sum of the participants' individual results the prime reason for most networks is to provide material for individual participants to make their own decisions and to develop future programmes.

9. Comparability of assessment. To be meaningful in combined analysis data from different collaborators should be strictly comparable in terms of method of assessment, precision and bias (or rather freedom from bias). Standard characters and methods can be prescribed in the protocol of collaborative research and in some networks different participating centres are responsible for assessment of different characters (e.g. the NAS nitrogen fixing tree network). For multipurpose trees the number of traits of interest is not yet fully known and simple, precise methods of assessment have not been developed for many. Some guidance is available in the ICRAF manual for the evaluation of multipurpose trees (Huxley, 1984) and there is a strong case for providing for one common assessment of all field trials by one person or team from the leading centre at an agreed, meaningful point in the trial's life (see e.g. Gibson, 1982, reporting on a single assessment of a sample of 12 sites in the CFI international tropical pine provenance trials).

CONCLUSIONS

Networking, twinning and multiple twinning offer means of enhancing staff development, speeding technology transfer, providing research material and guidelines not easily available to all potential beneficiaries, and yielding research results that are greater in extent and value than the sum of the individual activities that are components of the network. Various principles govern the success of networks; they encounter several types of problem, but these can be overcome, and the indication from extensive international agricultural networking, now supported by evidence from several forestry germplasm and management networks, is that networking is a cost-effective, politically acceptable, scientifically enlightening and stimulating approach to problems in the management and improvement of natural resources.

REFERENCES

Burley, J. and von Carlowitz, P. (eds.) (1984). Multipurpose tree germplasm. Proceedings of ICRAF/CFI/IBPGR planning workshop, Washington, DC, USA, 1983. ICRAF, Nairobi, Kenya, 295 p.

Burley, J. and Wright, H.L. (1984). Experimental design in multipurpose tree research. Invited pap. IUFRO Regional Planning Workshop for Asia, Kandy, Sri Lanka. 20 p.

Cooper, L. (1984). The twinning of institutions; its use as a technical assistance delivery system. World Bank Tech. Pap. No. 23, 46 p.

Gibson, G.L. (1982). Descriptions of seed sources and collections for provenances of Pinus caribaea. Trop. For. Pap. No. 12, Comm. For. Inst., Oxford, 98 pp.

Huxley, P.A. (1984). Manual for the evaluation of multipurpose trees. (6 sections paginated individually.) ICRAF, Nairobi, Kenya.

Ivory, M.H. (1984). In: Multipurpose tree germplasm (Burley, J. and von Carlowitz, P., eds.), ICRAF, Nairobi, Kenya, 241-8.

Jones, N. and Burley, J. (1973). Seed certification, provenance nomenclature and genetic history. Silvae Genetica, 22(3), 53-58.

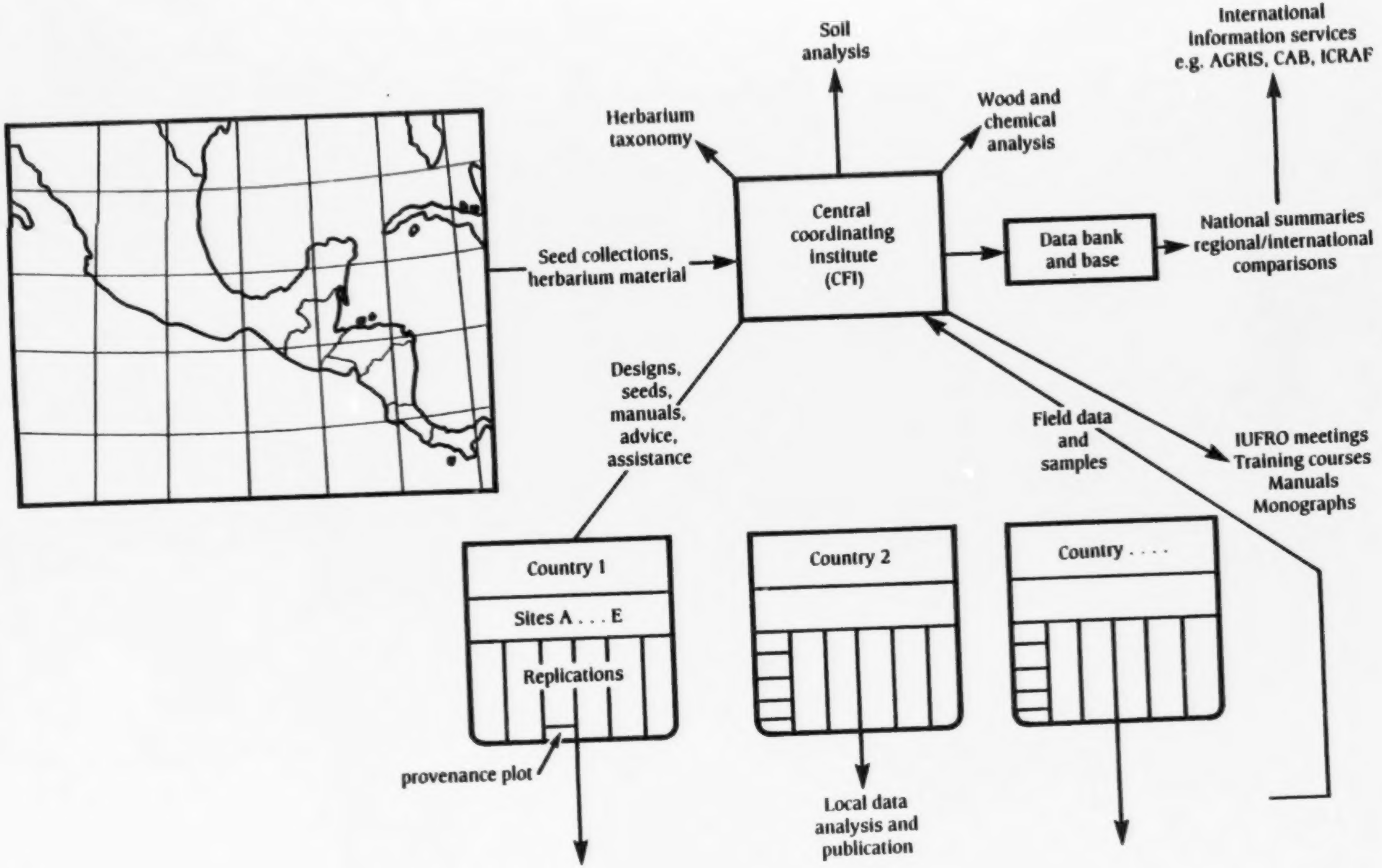
Plucknett, D.L. and Smith, N.J.H. (1984). Networking in international agricultural research. Science 225, 989-93.

World Bank and FAO. (1981). Forestry research needs in developing countries - time for a reappraisal? Spec. Pap. 17th IUFRO Congr., Kyoto, Japan. 56 p.

APPENDIX A

Example of a Functioning Network

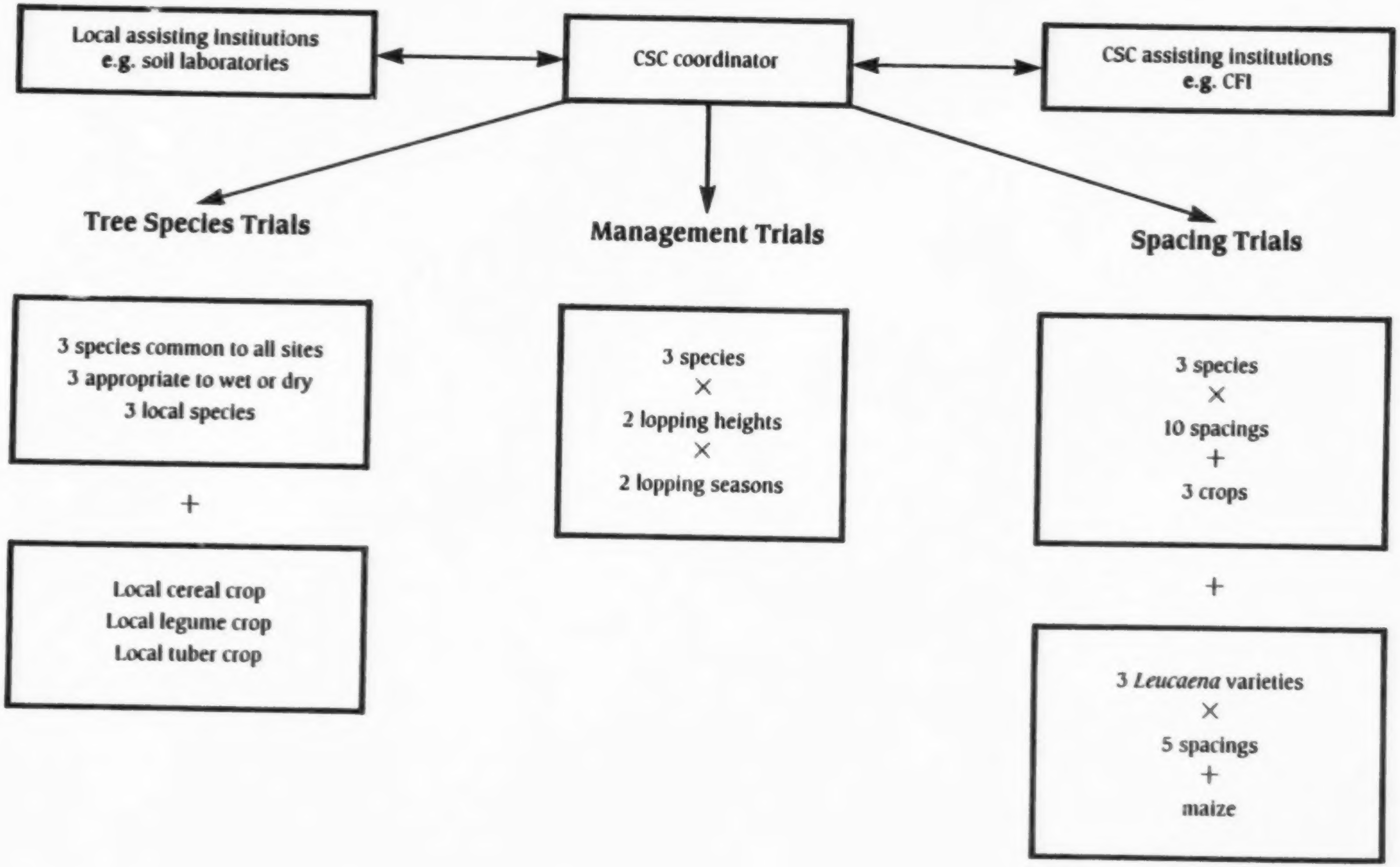
(Tropical Pine Provenance Research Network Coordinated by the Commonwealth Forestry Institute)


Soil analysis
International information services e.g. AGRIS, CAB, ICRAF
Herbarium taxonomy
Wood and chemical analysis
Central coordinating institute (CFI)
Seed collections, herbarium material
Data bank and base
National summaries regional/international comparisons
Designs, seeds, manuals, advice, assistance
Field data and samples
IUFRO meetings
Training courses
Manuals
Monographs
Country 1
Sites A . . . E
Replications
provenance plot
Country 2
Local data analysis and publication
Country . . . .

APPENDIX B

Example of a Proposed Network

(Agroforestry Network for Anglophone Africa Proposed by Commonwealth Science Council)


Local assisting institutions
e.g. soil laboratories
CSC coordinator
CSC assisting institutions
e.g. CFI
Tree Species Trials
Management Trials
Spacing Trials
3 species common to all sites
3 appropriate to wet or dry
3 local species
+
Local cereal crop
Local legume crop
Local tuber crop
3 species
×
2 lopping heights
×
2 lopping seasons
3 species
×
10 spacings
+
3 crops
+
3 *Leucaena* varieties
×
5 spacings
+
maize

APPENDIX V.

GUIDELINES FOR EFFECTIVE EVALUATION OF FORESTRY RESEARCH PROGRAMMES

G.R. Armstrong
International Council for Research in Agroforestry
Nairobi, Kenya

Evaluation of a research programme represents a search for efficiency. Fundamentally, one seeks to determine whether the expensive, often scarce, specialized human and physical resources employed are being used to good purpose to meet specified goals. To do this, one must first decide what constitutes good purpose, and whether there are other resource combinations that could more effectively meet that purpose.

Who should make such an evaluation? Those who will profit most from it are the research director and his staff. The wiser ones will perform such evaluations themselves, so that when others from outside the institution come to review its activities the research director will be able to explain and justify institutional actions, define institutional needs and demonstrate institutional contributions easily and effectively, without hesitation.

The process of evaluation and the process of research programme development are closely linked. If the programme is intelligently constructed, the evaluation will reflect it. Both the director and the evaluator will find that they have asked similar questions: what are the goals; what are the feasible ways of meeting them; which among these feasible alternatives are the best paths to follow; how do realized payoffs from the research compare with expected payoffs; if there are differences what are the root causes; and how can the programme be revised to generate larger future payoffs. Such questions may look easy to answer. They are not. Each merits some additional consideration.

What are the goals?

The basic goal of a research institution is not to conduct research or even to complete research projects. Whether public or private, general or specialized, basic or applied, the goal of the institution is to help meet the needs of its constituents through research. For public research institutions, a common and highly acceptable general goal is to help improve national welfare. Such improvement may be expressed in terms of rising incomes or employment, reductions in cost of living, or better quality of goods and services. It is knowledge of the special needs of clients that helps place emphasis on one or more of these values. The requirements of urbanites are not like those of rural residents; those of nomadic herdsmen not like those of valley farmers. So the first task of any research group is to look outside the organization, find out who its constituents are, and work hard to get to identify and understand their needs and problems. This external orientation is essential. It establishes the research not as an end in itself but as a means to an end. It provides a view of research as a service rather than as a product. And by directing attention to needs, it sets the stage for the next question, "by what logical paths can such needs be met through research?"

What Are the Feasible Alternatives?

Theoretically, the research possibilities for improving welfare are infinite. But many options are immediately ruled out by the special and often limiting needs and characteristics of the institution, or its publics, or the physical, social, political, scientific and economics environment within which it operates. Here in Kenya, for example, guidelines and recommendations by the government and by private constituents currently include requests for special attention to forestry problems of the arid and semi-arid zones, to forest establishment and replenishment rather than to management and development of existing forests, to farm forestry as opposed to industrial forestry, and to the relationships between forestry activity and soil protection, water supply and other environmental conditions. Thus, large sets of options are given emphasis and others, temporarily at least, given a lower priority.

Important internal constraints that affect choice of research topics, at least for the short run, typically include the institutional mandate; the numbers, types of specialization, education, experience and personal motivations of staff; the kinds of capital resources available to the institute; current commitments and programme responsibilities inherited from the past; and the prospective budget.

Environmental constraints may include such diverse items as geographic location of the research facility, predicted government expenditure patterns, current and planned activities of other research organizations, government rules regarding land ownership, local attitudes toward the utility of forest cover, and heavy grazing pressures.

In the last analysis, every aspect of the institutional environment makes its impact on the choice of options. Research personnel cannot hope to monitor them all. What they can do is to carefully review expressed needs and interests, both national and regional, with particular attention to how and why those needs might be changing; assess their own abilities to conduct research of various kinds; and monitor major changes in the scientific, economic, social, legal and political atmosphere so as to anticipate at least some of the factors that promise to realign research options.

What are the Best Paths to Follow?

Even at this stage of development, the potential research programs lacks specificity. Though the field of activity has been narrowed down by reference to external and internal limitations and preferences, the options are still numerous. Somehow, priorities have to be established among them.

To illustrate the selection procedure, let us assume that the mandate of our institution, as set forth in its charter, is to conduct fuelwood-oriented research, and that government has suggested strongly that research efforts be concentrated in the semi-arid zone. We have polled the forestry need of publics in that area and find that fuelwood scarcity is creating three kinds of problems: prices are rising in the towns; low income groups are more strongly affected than higher income groups because everyone needs fuel for cooking and heating and there are no ready substitutes; and in the rural areas more and more time an effort is consumed in gathering because fuelwood supplies must be found further and further away. Expectations are that these problems will get worse because the nearby forests are being depleted faster than they are growing; patterns of fuel use are not expected to change materially in the near future; and populations are rising.

A summary review of population distribution in the semi-arid areas reveals that population is concentrated for the most part in two large towns and is expected to rise most rapidly there. We reason that the greatest short term public benefit will accrue if we can, through research, devise methods to bring the fuelwood price down in these two towns (or even to keep it from rising). We suspect that the techniques we work out may be applied later in other areas with similar success. At this point in our deliberations we have finally developed a specific goal that can be expressed in welfare terms; to prevent fuelwood costs from rising in towns X and Y.

Next it is necessary to examine the various paths by which such a particular goal can be met. The easiest way to visualize the alternatives is to chart them, as in Figure 1. This is a staff function, and may require a lot of time and debate because the options are rarely immediately evident. The important thing is not to omit any major alternatives.

In this case, we know from our elementary economics that price is a function of demand and supply. Price reduction therefore entails either a reduction in demand or an increase in supply or both. To reduce the demand, what might we do? Figure 1 shows that one option is to develop substitutes. Another is to increase the heating and cooking value per ton so people will use less wood than before. Are there other options? Probably not. At least none come readily to mind. To increase the heating and cooking value per ton we can name further options. We can squeeze more value into the wood (by increasing its quality), or we can squeeze more value out of the wood (by improving the consumption technology). The diagram shows that in this way we can move from the general welfare goal to very specific, relatively narrow activities. All we have to do is to continue to break down the foregoing element into components.

This kind of general outline provides the key to selection of priority research areas. Much of what has been said at this conference has dealt with priority determination between and among institutions. Here, we are dealing with priority selection primarily at the project level. Although it continues to be something of an art, some scientific tools can be borrowed from the fields of economics and decisions theory to weigh the alternatives.

What the research director and his staff must do is to compare the costs and time expenditure expected in following a particular research path with the risks of failure and potential payoffs. In our example, staff specialists may have to estimate whether greater net research payoffs (i.e., greater price reductions) lie with the development of efficient wood fuel cookers or, say with the development of wood alcohol plants. To do this, they must call upon their research experience to determine what technical approach or approaches are most viable; to judge how long it will take to get results; to estimate what resource inputs will be required; and to predict both the chances of ending up in a blind alley (e.g. alcohol yields from available species are too low for the process to be economically feasible) and the potential payoffs of success (i.e., the probable effects on local fuel availability and price).

Such estimates as these are typically made by the research director and a small group of senior staff. They are typically subjective and often highly speculative. This does not sound like a solid foundation for the establishment of programme plans or decisions to go ahead with particular projects, but there is still another step which, if carried out faithfully, tends to repair errors of judgement.

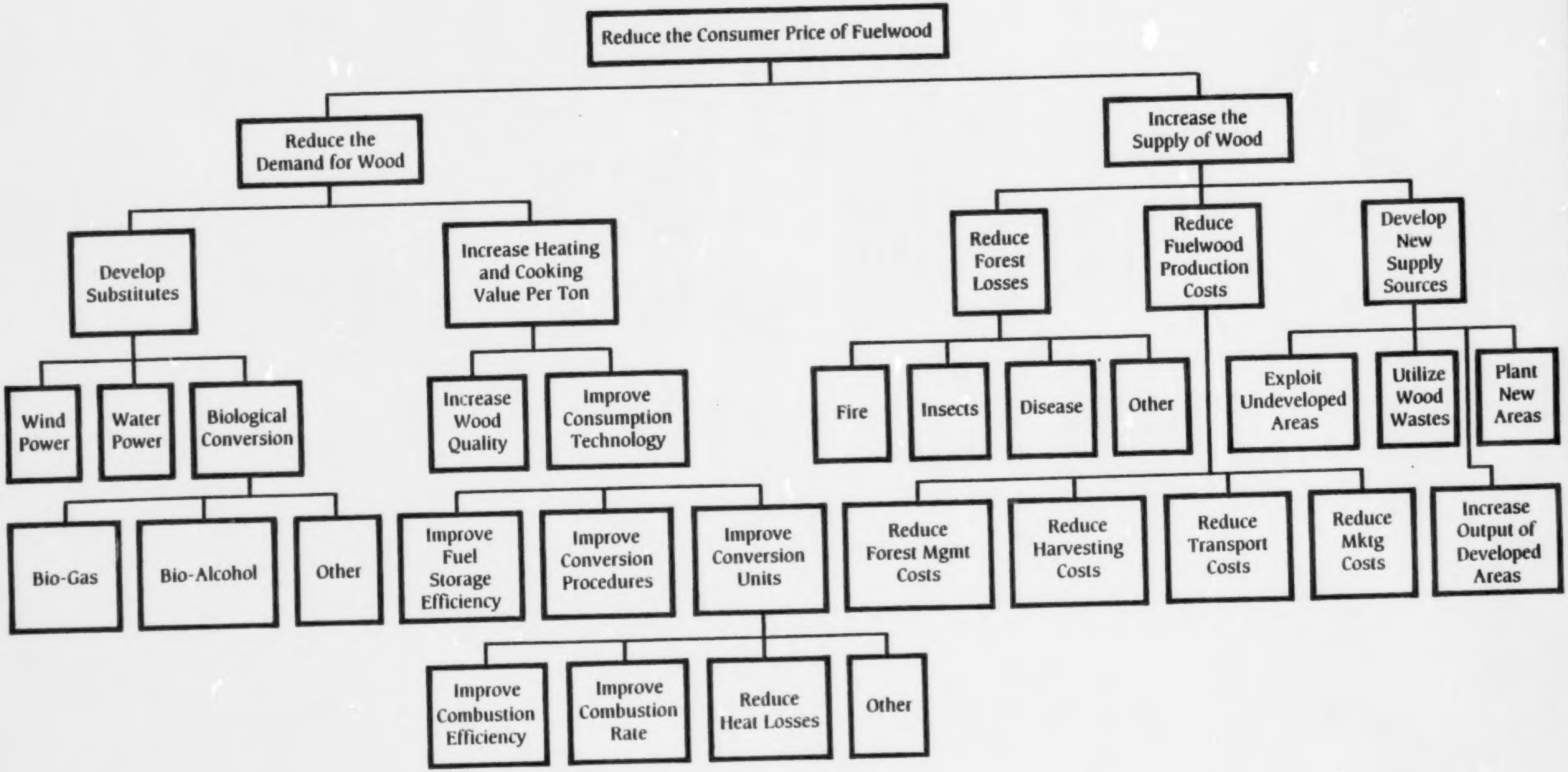

Reduce the Consumer Price of Fuelwood
Reduce the Demand for Wood
Increase the Supply of Wood
Develop Substitutes
Increase Heating and Cooking Value Per Ton
Reduce Forest Losses
Reduce Fuelwood Production Costs
Develop New Supply Sources
Wind Power
Water Power
Biological Conversion
Increase Wood Quality
Improve Consumption Technology
Fire
Insects
Disease
Other
Exploit Undeveloped Areas
Utilize Wood Wastes
Plant New Areas
Bio-Gas
Bio-Alcohol
Other
Improve Fuel Storage Efficiency
Improve Conversion Procedures
Improve Conversion Units
Reduce Forest Mgmt Costs
Reduce Harvesting Costs
Reduce Transport Costs
Reduce Mktg Costs
Increase Output of Developed Areas
Improve Combustion Efficiency
Improve Combustion Rate
Reduce Heat Losses
Other

Fig. 1 Partial Checklist of Options for Reducing the Consumer Price of Fuelwood

Measure Performance

We have noted that the decision to attack a particular research problem in a particular way rests on several estimates:

1. How long the job will take
2. What inputs (men, money, materials) will be required
3. The risks of failure (usually in percentage terms) together with recognition of possible reasons for failure.
4. The expected payoff in welfare terms.
5. Who will be affected.

As the project progresses, by establishing recognized benchmarks it is possible to measure how realistic those estimates were. Such feedback very often has a negative aspect. Projects fall behind schedule, more resources are required than were originally planned for, experiments fail. Researchers understandably don't like to draw attention to such outcomes, particularly if they feel such results will be misinterpreted because the wrong rules are being used in measuring success. But when such information is used constructively it can improve programme efficiency tremendously. It provides early warning for the need for adjustment in programme. It highlights opportunities for control of both internal and external factors. And it serves to improve staff skills at estimating inputs needs and the real time required to get certain types of jobs done.

What one does during this stage is to ask not only whether the job took longer than expected, or required more or less man hours, or paid off more or less than expected, but why these things happened. Sometimes it takes quite a bit of digging to understand why. But the experience gained in this way, over a period of time, generates ability to make increasingly better estimates and to reap more certain returns from the research programme.

What are the High Points of the Process?

In this very brief review, we have seen that development of an effective research programme depends first on understanding and agreement regarding whose needs are to be met and on thorough, careful study of what those client needs really are. Programmes dominated by the special interests of staff members are quite likely to be inefficient and often off target. Adopting an external viewpoint, and visualizing research as a service to others is a powerful stride toward introducing relevance and immediacy into research activities and reducing the isolationist, ivory-tower attitude that can come creeping in to obsure the relationship between what happens in the laboratory and what one's countrymen need in the way of forest goods and services.

The second step is to identify the major routes that the institution can follow in attempting to meet such needs. Like a good ship captain, the research director examines the strengths and weaknesses of his vessel and crew, the various types of perils and obstacles that they might encounter while trying to reach accepted objectives and heeds the guidelines and directives that are provided by authorities above him. These taken in combination, provide the basis for selecting certain routes for closer examination and for abandoning others.

The third major step is to select among the more promising research alternatives those that the institute feels will best meet the goals. This difficult step depends heavily on informed estimates by professional staff and administrators. It is a kind of subjective cost-benefit analysis performed before the work begins. It is critical, because it is on the basis of those estimates that major program decisions are made.

Finally there is feedback gained by monitoring the progress of projects that together make up the program. This periodic review of job schedules, input requirements, risk and payoff is of critical value in reallocating institutional resources and in otherwise adjusting the program to accommodate for change. In this step it is necessary to ask not only how reality compares with expectations but also why there is a difference and how this knowledge can be used to advantage in adjusting or redesigning the program?

There is one last point to be made. The ultimate utility of any research program rests in its application. Unless there is concrete evidence of increased welfare, the research program cannot pretend to be efficient. The last important step in research is always in seeing that the results are used.

Now we have come full circle, from recognition of the welfare goal to its partial satisfaction by means of a series of logical steps that a research director and his staff will want to take in order to increase their efficiency and contribution. Those outside the institution who have monitoring or coordinative roles can do no better than to follow through these same steps in close consultation with the director and staff and to examine the logic of the ways in which they are being handled.

There are certain characteristics of the system that merit further comment. It is complex. First attempts to use it are apt to fall short of the mark. It takes several years of diligent effort to learn how to carry out the several steps effectively. It is self correcting. Because the feedback loop provides for adjustment to changes in the system, the program is constantly open for improvement. It is broadening. Researchers using the system are encouraged to look outside their own field and institution for many of the forces that modify and guide their actions and decisions. In this way, the linkages between diverse events become more clear. The rationale for cooperative action is easier to understand and to endorse. It is protective. Those who work through the several steps are really creating a healthy justification for what they are doing. Critics are forced to abandon arbitrariness and to voice their objections on logical grounds, if they can. Furthermore, new staff are provided with a clear picture of goals, objectives and procedures that will guide them along lines congruent with institutional needs.

I hope you find such a system worthy of adoption. It comes highly recommended by those who have tried it.